SAPPER!

SAPPER: a military specialist who lays, detects and disarms mines.

The following is a series of lectures by a WW II British training officer with an expertise in mines. They were hand-written and unsigned. Ordinarily, I would have passed them over but the hand-drawn illustrations were so precise and beautiful I knew the author had a more than dutiful knowledge of his subject.

As I waded through his stylized handwriting I knew I had discovered a genius. He gives an overview of the craft which lends much beauty and majesty to possibly the most horrible segment of modern warfare.

There are gaps in the series, due to the fact that there was obviously no intent to publish. But the interested reader will gain much insight into both the philosophy and mechanics of this martial art. This insight cannot help but give a clearer understanding to other lesser works in this field.

Mines and booby traps have been of utmost importance but have seldom been given the recognition they deserve as one of the most effective adjuncts of anti-personnel warfare.

Eighty percent of the U.S. casualties in Vietnam were caused by mines and booby traps. The average G.I. never saw a VC but was demoralized by the knowledge that they were ever-present. Moreover, he knew that no matter how well trained and courageous he might be, he was most likely to lose a limb, or his life, to some gadget set out by a non-soldier, or even a child.

The Russian G.I.s were likewise demoralized by Afghan irregulars to

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EXPLOSIVES THEORY

(OPENING LECTURE)

An explosive is a substance, made up up of various nitrates and chemicals, and when suitably stimulated, decomposes rapidly from a solid into a gas with the liberation of intense heat, resulting in a sudden and intense pressure causing violent disruption of the air and its immediate surroundings. I.E , one slab of TNT expands in the form of gas, in one second, approximately 18,000 times its own size in space.

This rate of change, from a solid to a gas, is worked out in meters per second and is known as the violence figure of the explosive, i.e., rate of change. For instance, TNT is approximately 18,-000 miles per hour.

THE CLASSIFICATION OF EXPLOSIVES can be divided into three groups.

(a) Speed of Reaction (MPS)
(b) According to its Sensitivity.
(c) Service Classification.

The speed of reaction can also be divided into three groups:

(a) Combustion
(b) Explosion
(c) Detonation

Combustion. This is a chemical reaction in which oxygen from the air is embodied, usually accompanied by heat and there is always a liberation of gasses, i.e., as in a petrol engine. The violence figure on speed of reaction is up to a third of a meter.

Explosion. This is a rapid form of combustion. The heat is intense and large quantities of gasses are produced

suddenly, causing intense pressure and disruption, i.e., gunpowder, cordite and ballistite, etc. The violence figure is up to 3,000 meters per second. Both combustion and explosion can be produced by means of flash (spark flame), match, etc., and is mainly the expansion of burning gases, which rapidly requires room to expand and therefore gives a pushing or lifting effect to achieve this object.

Detonation. This is the ultra-rapid breaking down of a substance, proceeding through the explosive in the form of a wave, known as the "detonating wave". Detonation creates a cutting and shattering effect and depends on continuity. Therefore it will be halted by an air space. In detonation there is complete disintegration of any close object, so rapidly does it need to expand that it will cut through a substance or completely destroy it, in preference to moving it. Violence figure: 3,000 meters per second and upwards.

Up to 4,000 meters per second - Low Explosive
From 4,000 to 8,000 - High Explosive
From 8,000 and upwards - Very High Explosive

According to their sensitivity explosives are divided into three groups:
(a) Initiators
(b) Intermediaries
(c) Bulk Explosives

Initiators. An initiator represents a detonator or equivalent, such as fulminate of mercury.

Intermediaries. These are primers for boosting the detonating wave once it has been created, such as any of the sensitive explosives which can be initiated by detonator direct. (Gelignite or Nobel's 808).

Bulk Explosives. These are main charge or fillings, representing a bulk explosive such as TNT or Wet Gun Cotton, etc. These are of the non-sensitive variety, which must have a primer to initiate them, and any of the above intermediaries can be used for doing this. It will be noted that all intermediary explosives (sensitive) should also be primed to obtain the best results and power. An example; Gelignite initiated by detenator alone has a violence figure approximately 3-4,000 meters per second, but when primed, will be raised in the region of 8,000 mps.

Service Classification. This can be divided as:
(a) Propellence.
(b) High Explosives.
(c) Miscellaneous.

The power of explosives is judged by two standards:
(a) The rate of combustion upon detonation (violence figure).
(b) The volume of gas produced in relation to an explosive such as Lyddite (power figure 100).

Sensitivity. This is the term used to determine the ease with which an explosive can be detonated; high sensitivity naturally involves danger.

Stability. All explosives, to a certain degree, are unstable, otherwise they would not explode. Most explosives used in military services are relatively safe, but under certain conditions some tend to break down and decompose, resulting in deterioration in efficiency and safety in handling. For instance, Gelignite is affected by heat and cold. Obviously, bulk explosives cannot be manufactured or transported safely if they have a high rate of sensitivity. Therefore, in order to initiate bulk explosives, a number of accessories are necessary, such as initiators and intermediaries.

Initiators. First, of combustion or flash:
(a) safety match, (fuzee match).
(b) igniferous or percussion cap (flash cap).
(c) ampule or miner's igniter (chemically produced flash).
(d) friction igniter (German equivalent to a fuzee match).
(e) electric flash.

To prolong and carry the flash, giving a delay, safety fuse is used.
(a) fuse, safety. No. 2 MK II, (black), Burns under water.
(b) S.A. Commercial Safety, misc. packing. 24 ft. lengths.
(c) Bickford's Blue. Commercial Safety.

Burning speed of all three fuses, 2 ft. per minute.

Booby traps need no delay, consequently, instantaneous Orange fuse is used and is lighted with a naked flame (but never should be). Burning speed; 90 ft. per second.

More on Detonators: - three main types.
(1) No. 27 packed 25 to a tin, complete with rectifier. (8 tins to a box).

Rectifier: A device for converting alternating current to direct current.

(2) No. 8 commercial packed 100 per tin.
(3) No. 33 electric, packed 100 per

tin.

No 24 detonator is a service detonator and consists of a solid drawn-out aluminum tube 1 3/4" x .26" in diameter. To use with safety fuse, the fuse is inserted into the open end of the detonator, which is crimped, attaching both firmly to each other. The detonator consists of .35 grammes A.S.A. (lead azide, lead stypnate and aluminum powder) which is a very sensitive mixture, and which detonates .55 grammes of tetryl. The tetryl has the effect of amplifying the effect and power of the detonating wave set up by the A.S.A. From the open end inwards is a space of 7/8 c. which the fuse fits in, then comes the A.S.A mixture and lastly the tetryl (tetra. nitro-methyl analine). Very sensitive, the detonator is sensitive to friction and it supercedes the previous type, which was filled with fulminate of mercury. The commercial equivalent of the No. 27 detonator is the No. 8 Commercial and in fact, they are one and the same. But the No. 8 service detonator (now obsolete) is entirely different, being filled with fulminate of mercury and is considerably less powerful than the commercial No. 27.

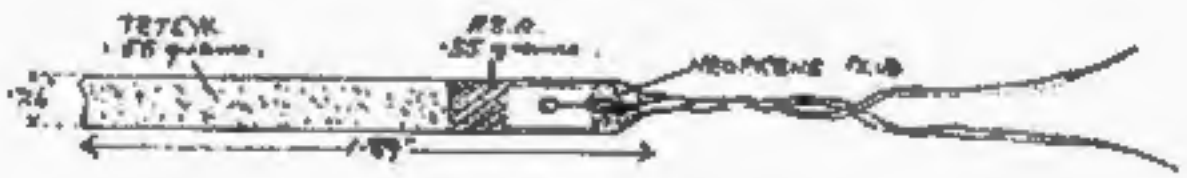
No. 33 Detonator is the standard electric detonator and it consists of an electric firing head crimped into the open end of a No. 27 detonator. A neoprene plug (rubber) seals the electric firing head in position and prevents moisture from entering and the electric firing head is a filament terminal of two wires. Lowest current fire is 8 amps and a 4.5 volt bellicon lamp is normally used.

Electric Fuse No. 31 is an independent firing head supplied for use in conjunction with a No. 27 or No. 8 detonator, by insertion in the end which normally receives the safety fuse. It is painted brown and one end is closed with a cork disc secured by shellac and between the cork disc and the filament is a small amount of guncotton. This is ignited by electricity and in turn ignites the A.S.A. which detonates the tetryl.

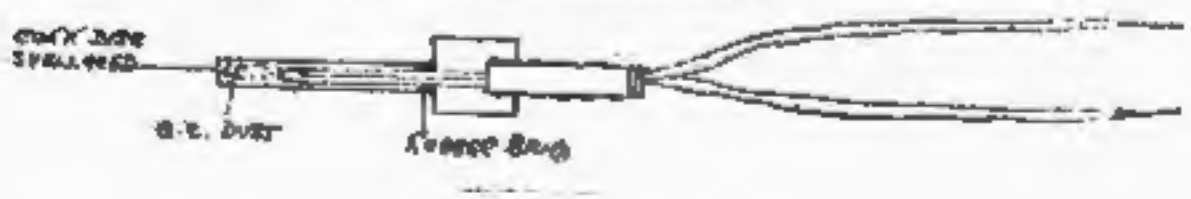
Commercial No. 8 submarine electric detonator is equivalent to the commercial No. 33, the detonating end (really a No. 8 A.S.A.) is exactly the same dimension as a No. 27 service detonator and can be used with a 1 oz. C.E. or D.G.B. primer. It is also aluminum in color. The filament is sealed in the detonator by adhesive tape, which renders it waterproof.

Intermediaries. Primers are used to boost the detonating wave set up by the detonation and is a large amount of less sensitive explosive. Two main types

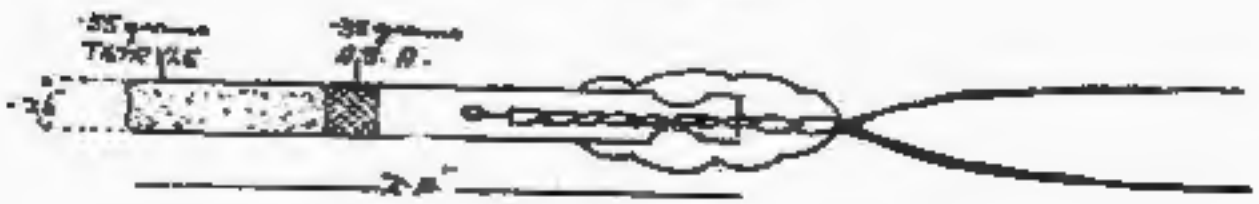
No. 27 DETONATOR.



No. 33. ELEC. DET.



No. 31. ELEC. FUSE.



No. 8. COMMERCIAL ELEC. DET.

of primers are: -
(1) dry guncotton primer, speed 7300 mps. (meters per second).
(2) Composition explosive (C.E.) primer. Speed, 7500 mps.

D.G.B. primers MK II, weight 1 oz. Slightly tapered cylinder of dry guncotton provided with an axial perforation to take a detonator. Length 1 1/4" They are 1.35" x 1.15" diameter at the larger and smaller ends respectively.

To differ from the obsolete MK I primers, which are marked with red figures and have a smaller axial perforation, the MK II is marked with black figures and takes a No. 27 detonator comfortably. Packed 10 per black tin cylinder weighing 16 1/2 oz. Six cylinders are packed in a box painted service color, the dimensions 13 1/8 x 5" x 6", weighing 13 lbs.

D.G.C. primers will initiate detonation in any high explosive, provided the contact is good and failures that may occur are usually due to absorption of moisture. To prevent this, they are coated with acetone, although the sides may easily become cracked or chipped.

When in good condition and undamaged, sensitivity will be retained even under wet conditions for six hours, but special precautions are necessary if primers are to be left in water for any length of time. Dry G.B. primers burn very readily if ignited, though detonation by heat alone is unlikely. It should never be cut or rubbed with steel, as friction may cause burning.

If it is necessary to provide a wider detonation hole, it is quite feasible to widen the axial perforation without splitting, as the primer being of G.B. is of a fibrous nature. A rectifier is provided with each tin of detonators and in the absence of a rectifier, a thin pencil is a good substitute.

MK I primers can be used with Service No. 27 detonators, although they were originally designed for use with the No. 8 detonators. If used with a No. 27 detonator, considerable rectification is necessary. Even so, it will be impossible to insert a detonator more than 1/2 inch. This amount of contact is adaquate. Dry G.B has been known to be detonated by a rifle bullet and care should be taken to minimize the chances of this happening.

C.E. Primers (composite explosive) is the service nomenclature for tetra-nitro-methyl-aniline and it is also known as tetryl. Pale yellow in color, it is sensitive enough to be detonated by a rifle bullet and is susceptible to damage by moisture.

C.E. primers may be substituted for outside dimensions, the powder is enclosed in a waterproof, waxed covering. The central, or axial, perforation is not tapered and is lined with waxed paper.

Rectification would split the paper and allow the powder to escape. To prevent this, the axial perforation is made slightly larger than the detonator, which will therefore need to be packed to insure a close fit. A piece of paper or even a blade of grass is usually adequate for the purpose.

C.E. primers are packed in G.C. tins or trade packages. 10 per cylinder. Trade cylinders are of waxed paper 12 1/2" x 1 3/8", weighing 1 lb. 3 oz. Ten of these cylinders are packed in a cardboard box weighing 14 lbs.

Main Charges or Disruptions.

Wet Guncotton Slab. Violence figure: 5500 mps. Power figure: Approximately 60.
Packing: - 1 lb. slab. 6" x 3" x 1 1/2". 14 per tin case 14 1/4 x 8' x 8 3/8", (airtight).
Composition: - Tri-nitro-cellulose, prepared by treating cellulose with nitric and sulphuric acids. When prepared, it is treated or processed into blocks and then treated with carbolic acid to prevent growth of fungus, and chalk to absorb any free acid remaining. A block contains 13% to 14% water.
Properties. It is extremely insensitive and a primer must be used. When dry, it will burn extremely violently. On detonation, large quantities of carbon dioxide are given off and therefore, it should never be used in confined spaces such as mines or underground tunnels.

When two or more crates are placed together, ond one is detonated, the detonating wave will not normally pass through the one remaining. But the detonating wave will pass through the tin seperately. One slab of W.G.B. will blast a hole its own size through 1" of steel, 10" of wood and 20" masonary. It is a high explosive with a good cutting power.

1 slab cuts 1" steel, 10" wood, 20" masonary.
4 slabs cuts 2" steel, 20" wood, 40" masonary.
9 slabs cuts 3" steel, 30" wood, 60" masonary.

Guncotton is an extremely safe explosive to handle and will absorb up to 30% moisture, but detonation is then rather unreliable and very much reduced. If used under wet conditions, it should

be protected by "bags" of G.C., 25 lbs. MK II or "bags" of G.C., 5 lbs. MK III. A slab requires a primer to iniate detonation and the primer fits into tapered hole in the center of the block. Italian equivalent: Fulmi-Catony.

TNT Slab or Flake. Violence figure 7500 mps. Power figure 65

Packing: - Slabs. 15 per wooden box weighing 26 lbs. 14"x9"x8" or 14 per G.C. in a crate weighing 28 lbs. 1 1/4 lbs. 6"x3"x1 1/2",

Flake. 50 lbs. per wooden box.

Composition: tri-nitro-toluene.

Properties. Very stable if pure but liable to explode if in impure state. Not very liable to sympathetic detonation (set off by nearby detonations). Light yellow in color. Bach slab is painted with acetone to protect against moisture. The primer fits in a central tapered hole as with the W.G.C. (wet gun cotton) slab, which is approximately the same in power, sometimes known as tetryl.

Gelignite. Violence figure:- 6000 mps
Power figure 80

Packing:- 4 oz. and 8 oz. cartridges packed in cardboard boxes weighing 5 lbs., 10 boxes to a 50 lb. wooden box. The explosive is wrapped in waxed paper to prevent actual contact with the other cartridges.

Composition:- Nitro-Glycerine 40/60%. Sodium potassium nitrate 20%. Wood meal or collodion cotton 40/20%.

Properties:- Liable to exude nitroglycerine at extremes of temperature. Primers should be used, but will detonate without. It is more sensitive than any other normal service explosive. Belonging to the nitroglycerine group, gelignite is largely used commercially for borehole charges and they may be frequently met in service. It burns quietly in small quantities in the open. But if confined or if the cartridges are bulked together, detonation may occur.

All types of of the gelignite group are liable to cause headaches if bare explosive is handled. It is sensitive to friction. It is liable to detonate if struck by a rifle bullet.

It is issued in two types:- Firstly, its freezing point is many degrees below 0° centigrade. Second type, not of low freezing point with a disadvantage of freezing at 46° F. in which state they are dangerous to handle and use. For these reasons, commercial gelignites are not ideal for service use, but their plastic form makes them suitable for use in boreholes. The most common NG explosive likely to be met is Polar. NS Gelignite (50% NG) consisting of a jelly of 7% collodion cotton in nitroglycerine mixed with 50% of nitrate of soda.

It has the power of NS Gelignite and its sensitivity to detonation is not rapidly affected by moisture. Continued storage under wet conditions or prolonged immersion in water, however, causes the nitrate of soda to dissolve and forms a solution which exudes from the explosive. This solution is not dangerous, but it may carry with it some nitroglycerine. This may be detecyed by its oily nature. It is only these drops of NG which are dangerous and under these circumstances, gelignite should be handled with care.

When used for borehole charges, Gelignite should not be removed from its wrappings and tamping should be done firmly and gently with a wooden rammer, squeezing and pressing the explosive into position, not on any account thumping or using blows.

Gelignite can be reliably initiated with any detonator or detonating fuse. But best results are obtained by using a primer, which must always be used with explosive when used as a cutting charge.

Ammonal.

The name of *ammonal* is applied both to certain blasting explosives which contain aluminum and to military explosives, based upon ammonium nitrate, which contain this metal. Military ammonals are brisant and powerful explosives which explode with a bright flash. They are hygroscopic, but the flake aluminum which they contain behaves somewhat in the manner of the shingles on a roof and helps materially to exclude moisture. At the beginning of the first World War the Germans were using in major caliber shells an ammonal having the first of the compositions listed below. After the War had advanced and TNT had become more scarce, ammonal of the second formula was adopted. The French also used ammonal in major caliber shells during the first World War. All three of the above-listed explosives were loaded by compression. Experiments have been tried with an ammonal containing ammonium thiocyanate; the mixture was melted, and loaded by pouring but was found to be unsatisfactory because of its rapid decomposition. Ammonal yields a flame which is particularly hot, and consequently gives an unduly high result in the Trauzl lead block test.

	German I	Ammonal II	French Ammonal
Ammonium nitrate	84	72	88
Trinitrotoluene	30	12	..
Aluminum flakes	16	10	3
Stearic acid	..	..	9

Ammonal is also largely used commercially and such types are generally more sensitive than the military variety and many are liable to be detonated by a rifle bullet. Such Ammonals need

only a detonator or detonating fuse for iniation. But a primer should always be used on service Ammonal to insure detonation.

The commercial equivalent most likely to be met with is No. 704 in 25 lb. tins, two tins per box, weighing 60 lbs. It contains no charcoal, being light green in color and has the same power and characteristics as military Ammonal.

The above are the main types likely to be met with. Following are some of the lesser used bulk explosives and their compositions. They are often used in smaller quantities or in cooperation with others.

Melinite. A standard French explosive, mainly composed of tri-nitro-phenol (picric acid). It should always be kept dry, as it reacts with most metals to form very sensitive Picric salts.

When moist it is vivid yellow in color. It should be handled with extreme care and it is liable to Sympathetic Detonation. Gases formed on detonation are very poisonous, and when mixed with air, are highly flammable. Therefore, Melinite should never be used for offensive mining.

It is obtainable in slab form or as a powder. Slabs are yellow-gray or brown in color. The powder consists of small, straw-colored crystals, with a very bitter taste.

Melinite is not sensitive to shock and will burn in free air without detonation. The powdered form, known as pulverelent, is more sensitive than the slab form and is used either as a primer or separately for the less sensitive slab form.

It is supplied in the following forms: (1) Cylindrical cartridge. Weight of 100 grammes, 3.22 oz. Total weight of package, 130 grams or 4.18 oz. It is used for boreholes or in camouflets.

Explosive, 135 grams, 4.35 oz. Total weight 190 grams, 6.12 oz. Cutting or mined charges. These charges are also manufactured in five more sizes, ending in 20 kg., 44 lbs.

The cylindrical cartridge is composed of the powdered form and needs only a detonator or detonating fuse to initiate detonation. The petards consist partly of slab Melinite and partly of the powdered form. A detonator or detonating fuse is therefore sufficient to initiate the petards as well as the cartridges.

Both petards and cartridges are supplied in sealed tins and the lids can easily be moved to gain access to the detonator socket. This socket is too small for the average British detonator as the detonators intended for use are fulminate detonators used only with fulminate of mercury contained in a copper tube. Violence figure 7250 mps. Power figure 100.

camouflet (F. pron. ka-mŏ'flā), *n.* [F., smoke puffed into a sleeper's face; origin unknown.] *Mil.*, a mine with a charge so small as not to produce any crater when exploded. Such a mine is often sunk in the wall of earth between two parallel galleries, in order, by blowing the earth into one of them, to suffocate or cut off the retreat of the miner who is at work in it. When used for this purpose it is also called a *stifler*.

petard (pē-tärd')

An engine of war used to blow in a door or gate, form a breach in a wall, etc. It came into use in the sixteenth century, and in its early forms was a kind of mortar of iron or bronze which was charged with about seven pounds of gunpowder, rammed down and wadded, and fixed by means of rings to a stout plank, which was then attached to the surface to be blown in. The use of bombs has rendered the petard almost obsolete, but as still occasionally employed it is a cubical box of stout oak-wood, charged with twenty pounds or more of powder, and fired, like the older forms, by a fuse.

Petardeer Firing a Petard.

Lyddite. This equivalent to the French Melinite. The German equivalent is Granate Fulling. Composition: Trinitro-phenol. Properties. It should always be kept dry as it reacts with most metals to form sensitive Picric salts, liable to Sympathetic Detonation. Its gases are highly flammable when mixed with air and are also highly poisonous. Violence figure 7250 mps. Power figure 100.

Fulminate of Mercury.

Composition. Precipitated when a solution of mercury in nitric acid is heated in methyl alcohol.

Properties. Fine, sandy crystals. Very sensitive when dry but comparatively insensitive when wet. Sensitivity increases if compressed. It reacts with metals to form sensitive metallic salts. Detonation will occur when dry if subjected to friction, percussion or flame. Violence figure 4500 mps.

Cap Composition. This is made from Fulminate of mercury, potassium chlorate, antimony sulphide and mealed gunpowder. Properties. These give an igniferous

flash only. Fulminate of mercury increases the sensitivity of the composition. Potassium chlorate, owing to its richness in oxygen, increases the heat of the explosion. Antimony sulphide prolongs the flash flame effect. Mealed gunpowder diminishes the violence of the explosion.

A.S.A. Violence figure 4500 mps. Composition. A mixture of Lead azide, Lead stypnate and aluminum dust. Properties. Used in conjunction with a small quantity of composite explosive (Tetryl) in modern detonators. Fairly sensitive.

Lead Azide. Violence figure 4500 mps. Composition. Salt of hydrazoic acid, prepared by using soluble salts, such as lead acetate with sodium azide. Lead azide is precipitated out in fine white crystals.

Properties. Initiated by flame. Not reliable by percussion or friction and is fairly stable. It is fairly sensitive when compressed. Addition of water does not decrease sensitivity, and if exposed to moisture for long periods, it decomposes and forms compounds liable to spontaneous combustion.

Lead Stypnate. Violence figure 4500 mps. Composition.Normal salt of stypnate acid is precipitated when lead acetate and magnesium stypnate are mixed. Properties.Initiated by flame, it is fairly insensitive. Addition of moisture does not reduce insensivity but pressure does.

Composite Explosive. Violence figure 6000 mps. Composition. Tri-nitro-phenol-nitromene, commonly known as tetryl.

Properties. It is readily ignited by flash but if initiated by detonator, gives complete detonation. It is unaffected by moisture or temperature.

Penthrite. Violence figure (Cast) 6000 mps. (Powder) 6500 mps.

Properties. It is only used in detonating fuses, such as primacord and cordite. It is sometimes called PETN (Pentaerythrite tetranitrate). Used by the enemy (Italians) as a bulk explosive. It can be detonated direct, also initiated by flash and will burn violently.

Shellite. Violence figure 6800 mps. Power figure 85.

Composition. A mixture of trinitophenol and dinitrophenol. Properties.Very stable when dry but liable to Sympathetic Detonation. Internally reacts with most metals to form a sensitive salt.

Amatol. Violence figure 6500 mps. Power figure 114. These figures are for "40/60" compositions of which is as follows:- 40% ammonium nitrate, 60% TNT. A second type is known as "80/20" composition of which is, ammonium nitrate, 20%, TNT, 80%

Properties. 40/60 can be poured but 80/20 must be screw-filled with an Archemedian screw. A primer is essential. This explosive is fairly stable, providing the TNT is pure.

Baratol. Violence figure 5000 mps. Power figure 85.

Composition. Barium nitrate 20%, TNT 80%. Properties. This explosive is sometimes known as 20/80 Baratol and is extremely stable.

Used in powder form in grenades, mortar bombs and sometimes mines. Barium nitrate being a heavy salt, packs very well and is unaffected by moisture or temperature.

A primer should be used but small quantities will detonate without one.

Gunpowder. Composition. Potassium nitrate 75%, charcoal 15%, sulpher 10%. (Percentages are by weight). Properties. A lifting charge. It is black in color.

Ballistite. Composition. Soluble nitrocellulose and nitroglycerine soluble in acetone. Properties. Produces a large volume of gas.

Cordite. Composition. It is pure guncotton dissolved in nitroglycerine, stabilized and formed into sticks.

There are three main types of detonating fuses, as opposed to fuses which detonate primers. They are Primacord, Cordtex and FID (Fuse Instantaneous Detonating).

Fuse Instantaneous Detonating. Tatyl. MK III.

FID consists of a lead and tin alloy tube .23" in diameter filled with pure TNT (Tatyl). This is wound on a metal reel in 400 ft. lengths and contained in a yellow tin cylinder weighing 46 lbs.

Violence figure 5000 mps.

Principal uses. (1) To fire a number of charges simultaneously when firing by safety fuse. (2) To avoid excessive lengths of safety fuse, which would otherwise be required in certain demolitions. (3) As an adjunct to electrical firing, where there are so many charges to be fired that the detonators will be beyond the power of the exploder. (4) To avoid the use of detonators in boreholes or camouflets mined charges. (5) To widen the hole made by the camouflet equipment tube. FID is perfectly reliable provided precautions are taken.

This particular mixture of TNT readily absorbs moisture, causing it to become insensitive. Consequently, 6" should be cut off before starting to use

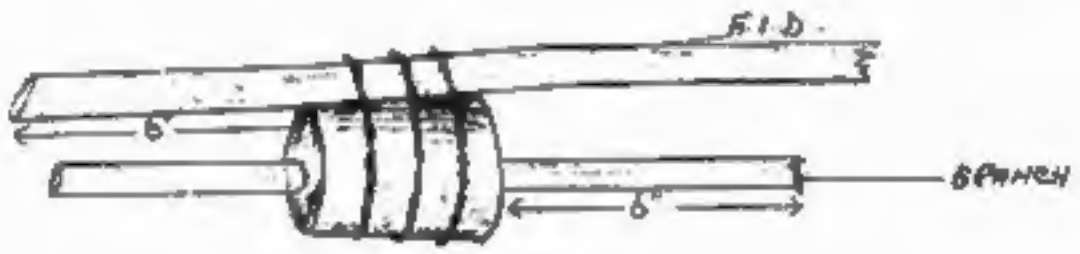
the drum and 6" should always be left spare at initiating points and at junction boxes. Ends left for any length of time should be sealed, taped with insulation tape or closed by pinching the cord out for approximateley 1/4" and sealing the lead sheath by squeezing together.

The fuse can be used under water as the metal case provides adaquate protection. It is perfectly safe to handle and is initiated either by a single primer or by three detonators. The single primer method is easiest to use. The single primer method binds the primer to the end of the FID, leaving 6" to spare.

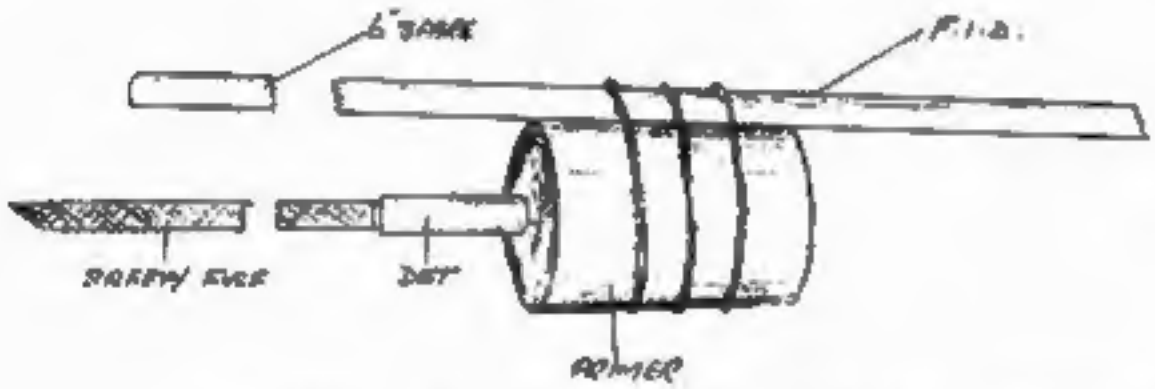
Method of Initiating FID, Single Primer. Rubber or adhesive tape makes the best binding. But ordinary tape or string can be used. Successful joints can also be made by using the cardboard outer container of the primer, the FID being held between the primer and cardboard. The three detonators method is not sufficiently reliable using the No. 27 or No. 8 commercial detonator.

FID will initiate direct all explosives that can be detonated alone. In all other cases the end of the FID should be capped with a primer. Where it is necessary to join two lengths of FID or to boost long lengths. (Boosting is required every 100 yards). A single primer should be used, as follows.

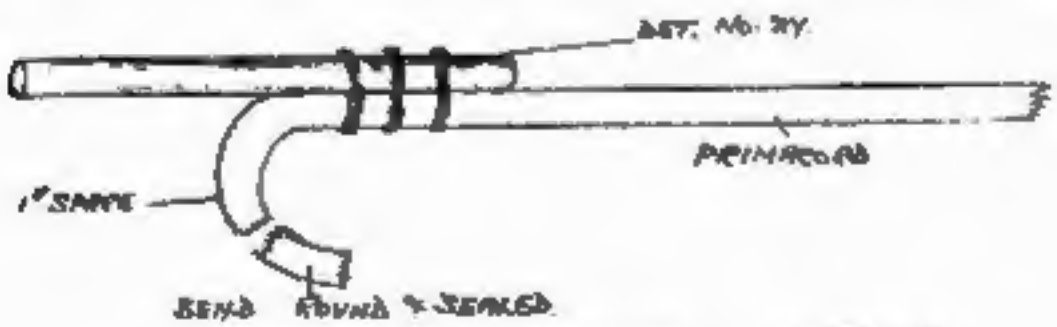
Cordtex. This is a commercial detonating fuse consisting of a sensitive explosive (PETN) wrapped in a gray fabric tube, with or without cotton cover-



JOINTING F.I.D.



METHOD OF INITIATING F.I.D. SINGLE PRIMER.



METHOD OF INIATING CORDTEX OR PRIMACORD

ing. Outside diameter is .19" and it may be issued on service in lieu of FID.

A single strand of Cordtex is unlikely to be detonated if struck by a rifle bullet. Junction boxes of the fuse have, however, been detonated by impact of bullets and should, therefore, be placed with care away from hard backings and in a situation where there is the least liklihood of impact. Drums of fuse are unlikely to be detonated if struck.

Cordtex is liable to damage by moisture at the open ends and one foot should be cut off from the drum before use and one foot left over spare at each point of initiation or junction.

Cordtex is absolutely liable to detonate in hot climates and so should be stored in a cool place.

Cordtex is packed on wooden reels of 500 ft., weighing 9 1/2 lbs. Five reels per case weighing 67 lbs.

Cordtex can be initiated by a single No. 27 detonator, or equivalent, as shown.

Method of Initiating Cordtex. It is very important that a spare end be bent back, as otherwise there is a danger of the burning fuse igniting the Cordtex core and preventing detonation. It will initiate direct any of the AG group or PE2, but a primer is required for other explosives. Speed 6000 mps.

Primacord. Very similar to Cordtex in composition and use to a good quality Cordtex. It consists of a case of PETN surrounded by cotton braid and enclosed in a coat of bituminous waterproofing compound, followed by a layer of phofilm tape and two layers of spirally applied cotton yarn, the whole being finished by a light-yellowish orange colored wax composition.

The external diameter of the fuse varies between .200" and .210" and it is wound on a wooden reel with a central hole for easy handling. It comes in lengths of 500 ft., weight 12 lbs. and 1000 ft. 20 lbs.

A reel may contain one or more splices, which are as strong as unbroken lengths and will detonate properly under all normal conditions. The explosive core is liable to damage by moisture and one foot should be cut off from the drum before use and one foot spare at each point of iniation or junction. Ends can can be sealed by fixing empty detonators tubesonto the fuse by sealing compound and when sealed, the fuse is highly resistant to water penetration.

The speed of detonation is approximatuly the same as that of Cordtex and is not less than 6000 mps.

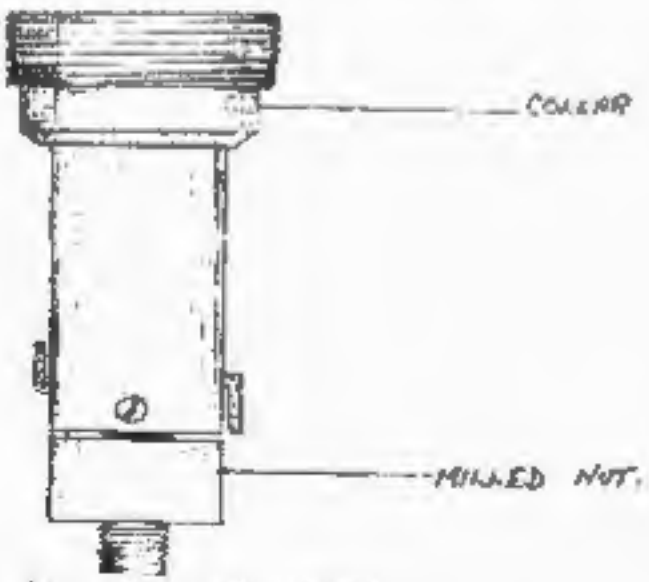
While single strands of fuse are not likely to be detonated by a rifle bullet junction boxes should be protected and placed with care away from hard backings.

Primacord does not deteriorate quickly, even under unfavorable conditions of storage.

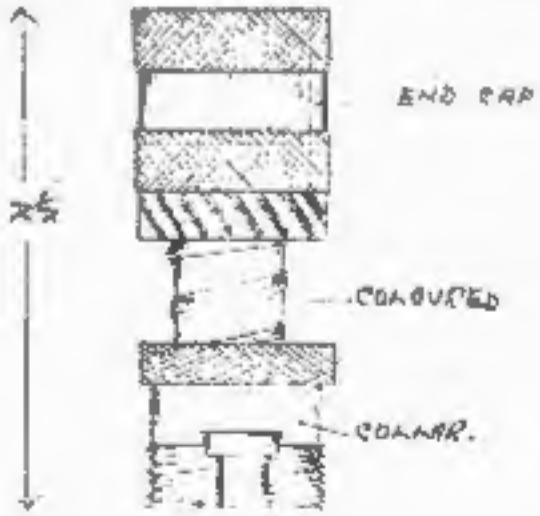
Primacord will initiate direct any of the NG group or PE2 but a primer is needed for all other explosives.

Joints are made in a similar manner to Cordtex, the most suitable being a reef knot for main lines and a clove hitch or two half hitches for branch lines. Branch lines, after leaving the main lines at right angles, should be led off in the general direction of the detonating wave. These joints permit considerable strain being put on the cord.

A fourth type of detonating fuse is Cardeau detonant, which is similar to a service FID except that the tube is composed of lead instead of an alloy of tin and lead. Special care should be taken to see that there are no kinks or severe bends in the fuse. Any position where there is any doubt as to the severity of the bend should be boosted by tying on a detonator or a primer.



TIME DELAY IGNITER.



CHEMICAL TIME DELAY IGNITER

TIME DELAY IGNITER.

TIME DELAY IGNITER.

This consists of a galvanized steel tube in which the cocked striker is retained by a lead shear pin. A milled nut screwed on the protruding end of the striker relieves the shear pin of the

strain of the striker spring until the striker is set for use.

The prepared detonator slides into position through the cutaway portion of the nut, which latter retains the detonator when the nut is tightened. The time delay is not accurately known, but specimens have given delays up to 26 hours.

To arm the igniter. Unscrew and remove the milled nut.

To neutralize.

(a) Grip the protruding striker firmly close up against the head of the igniter with a pair of wire-cutting pliers.

(b) Unscrew the igniter and remove the detonator by slackening the collar, then remove the pliers.

CHEMICAL DELAY IGNITER.

This consists of an aluminum body containing a cocked striker which is retained by a celluloid disc. When the igniter is armed, a quantity of acetone is released to surround the celluloid disc, which, after a certain lapse of time, is sufficiently softened to allow the release of the striker. (Use plastic today).

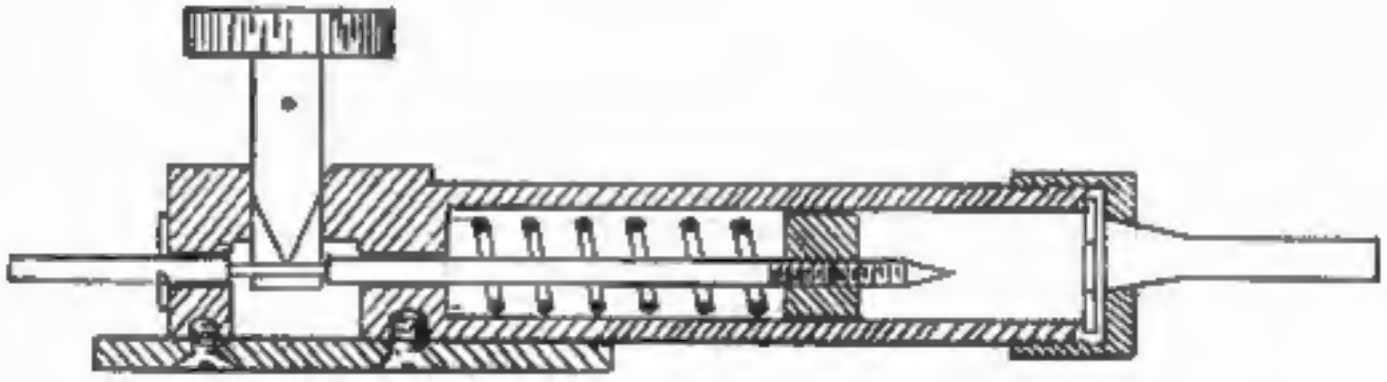
Different times of delay are indicated by the color of the threaded portion in the middle of the igniter body. From a limited number of tests, the following times have been obtained:-

Bright aluminum	1.45 hours
Steel gray	2.03 hours
Red	3.00 hours

To arm the igniter.

Withdraw the U safety pin, holding the igniter with the end cap downwards. Then screw in the cap to its limit.

This igniter cannot be disarmed. If found in an armed condition it should be unscrewed from the charge immediately and the detonator removed via the collar.



Pressure Switch

BRITISH SWITCHES.

Pressure switch.

The pressure switch consists of the following parts:-

(1) Main casing and base plate.
(2) Striker rod, block and spring.
(3) Shear stud.
(4) Adapter and collar.

The main casing is made of brass. In the base there are small holes for attachment to any suitable surface. The striker and rod are made of cast iron 1/8" in diameter, reduced to 1/16" under the shear stud, which will break it under a point load of 30-40 lbs.

A heavier striker is also available, which is 3/16" in diameter, reduced to 3/32" under the shear stud and will fire under a load of 60-80 lbs.

The metal shear stud is provided with a V shaped cutting edge and shoulders to keep it in position on the striker rod.

The adapter and collar are fitted with a service cap, and designed to take either safety or instantaneous fuse.

When a load of 30-40 lbs. is applied to the top of the shear stud, the striker rod will be sheared, allowing the striker to be driven forward by the spring and firing the cap and charge.

Pull switch.

This consists of a barrel in which moves a striker block, with a tubular tail split into four quadrants. On the end of each is a small lip. In the set position, these quadrants are splayed outwards by the point of the firing pin which is pressed forward by the retaining spring in the top collar.

The striker is then held up against the firing spring, by the lips on the tail engaging with a platform in the head of the barrel. Screwed on the bottom of the barrel by means of another collar is an adapter with a cap, also for the firing of the igniter safety fuse.

When the firing pin is pulled outwards, with a force of 1 lb., the split tail contracts to normal, enabling the lips to pass through the platform in the head and the striker to be driven down on the cap by the firing spring.

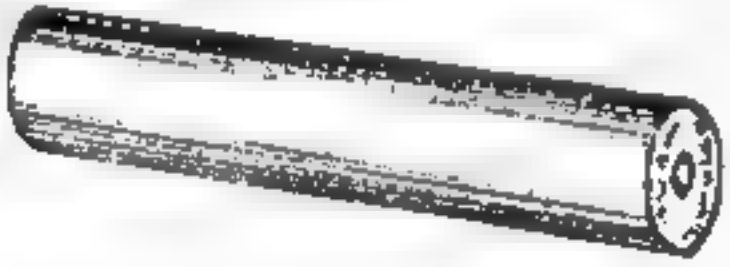
Time pencil fuse.

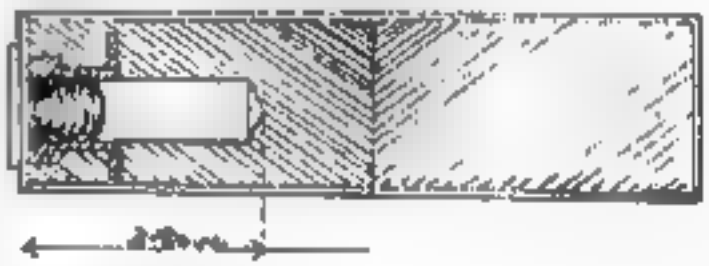
The time pencil fuse consists essentially of the following parts:-

(1) A thin copper sleeve containing a phial of corrosive liquid.
(2) A thin aluminum sleeve.
(3) A striker with spring and retaining wire.
(4) Fuse adapter and firing cap.
(5) Safety-pin.

The striker is held back against the spring by a thin, steel wire anchored to the top of the copper sleeve. When this copper sleeve is crimped and the phial is broken, its contents of corrosive liquid attacks the striker retaining wire. When this steel wire is eaten through, the striker fires the cap in the base and, in turn, the charge.

It is important to note, that the copper sleeve must be crimped flat and not bent round and the safety-pin withdrawn. Two fuses should be used for each important charge to guard against risk of failure.



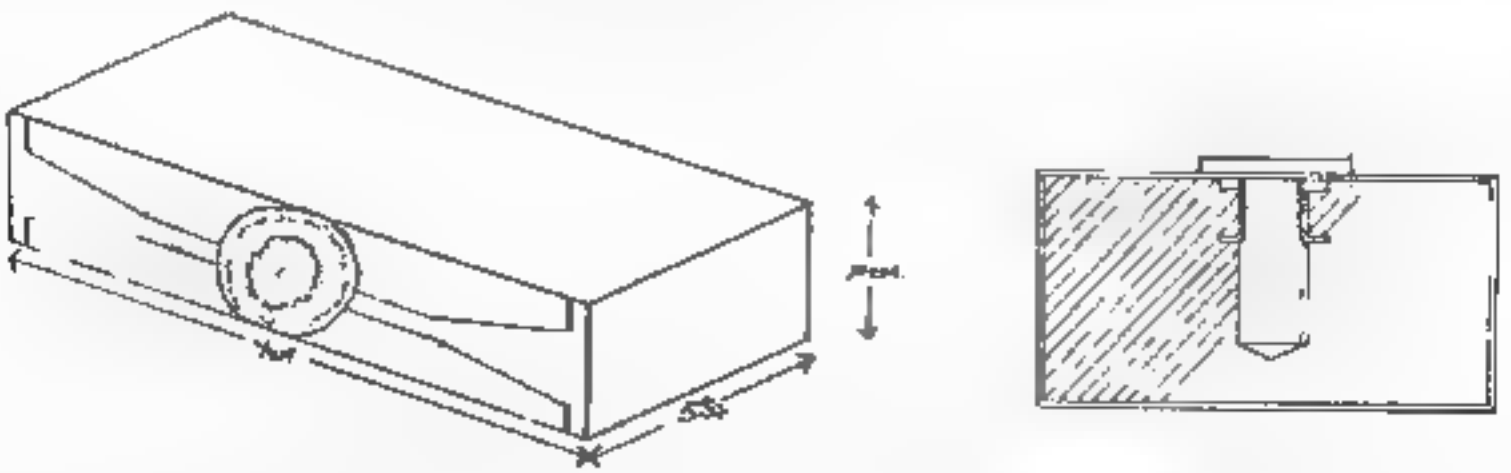


Solid prepared Charge.

Solid shrapnel charges.

The following prepared charges consists of high explosive wrapped in varnished paper and contains a screwed metal bush for inserting a prepared detonator or igniter Pull or Push, etc.

Small bore-hole charge, (cylindrical) 100 grams = 3.5 oz. which can be either Tolite or Picric acid.



Rectangular Charge. 200 grams = 7 oz.

Rectangular Charge 200 grams = 7 oz. This resembles a cake of soap, screwed metal bush on one side with standard threaded bush, for prepared detonator or igniter (Pull or Push, etc.)

The following prepared charges con-

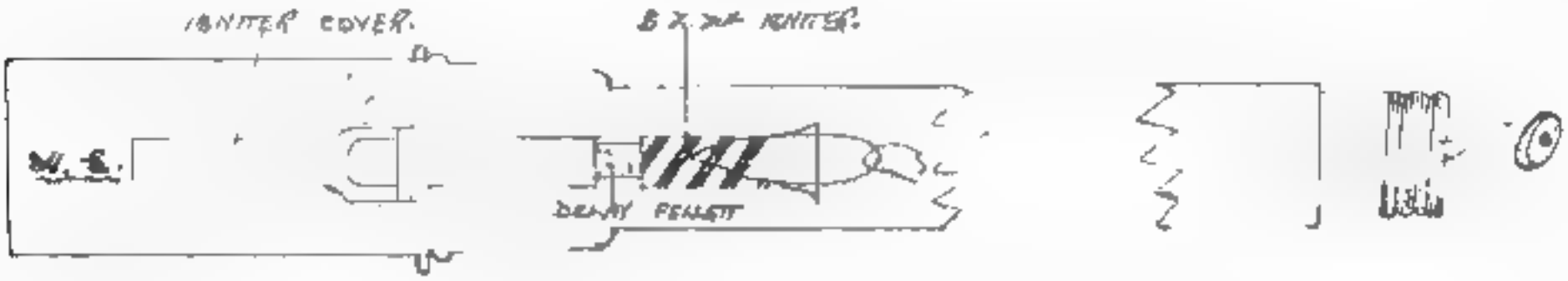
sist of solid high explosive in a metal case.

(a) Medium HE charge. 1 Kilo 2 lbs. Metal container, consisting of rectangular metal case containing TNT or Picric acid explosive, 3 standard threaded metal bushes on different sides to fluctuate their groupings to form demolition charge of any weight.

(b) Heavy HE charge 3 Kilo 6.5 lbs. Contained in metal case as 1 kilo block. 3 standard threaded metal bushes on different sides. Has carrying handle fitted to top, mainly for bridge demolition.

Contents: Picric acid or Tolite.

The explosives are either as above, labels cover each of the bush holes and are either yellow or orange. Yellow indicates Picric acid and orange indicates Tolite. The labels are naturally pierced when inserting the detonators.



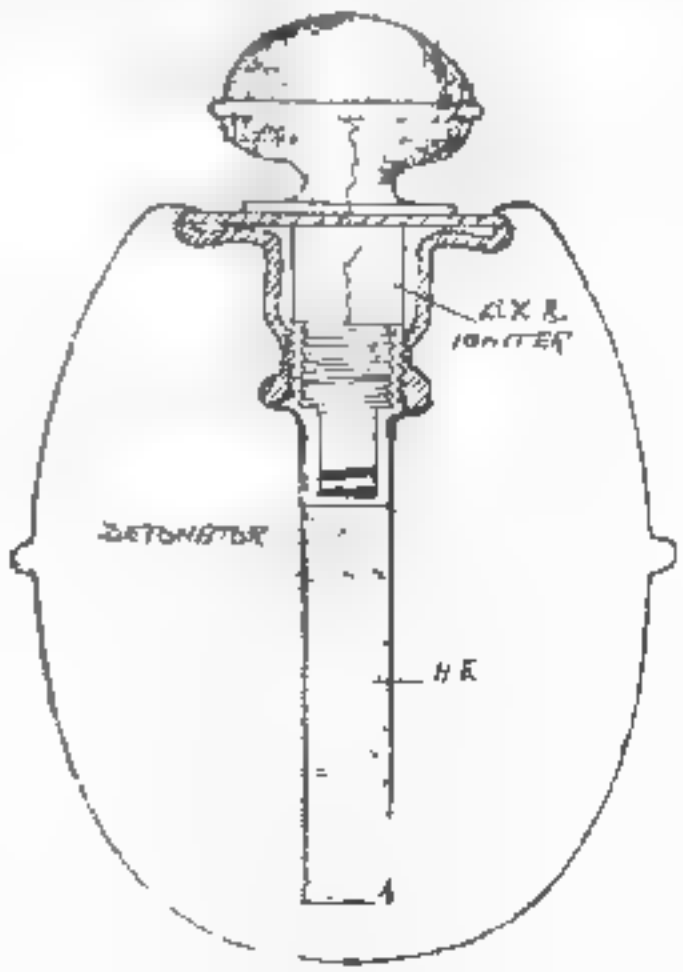
GERMAN STICK GRENADE (Blast)

GERMAN STICK GRENADE (Blast)

The 'Potato Masher' contains 3 1/2 oz. of explosive complete with detonator. It has a hollow handle at which one end is a cord, the third part being a base cap.

The igniters are known as the BZ .24, which is a friction, time delay igniter having a 4 1/2 second delay. The igniter has a lead tube containing the explosive, which has a wire attached to which the cord is also attached and threaded through the hollow handle. The igniter is screwed into position, with the wire and dust cap on the end of the handle.

The NBZ .38 is the same as the BZ .24 except that it has a white band painted round the lower portion of the lead body. It is used as a smoke grenade.



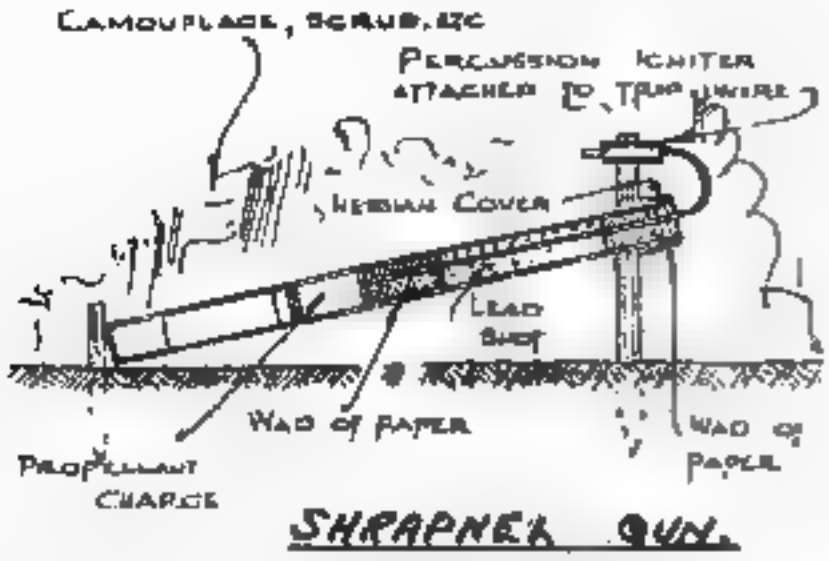
GERMAN EGG GRENADE (Blast)

GERMAN EGG GRENADE (Blast)

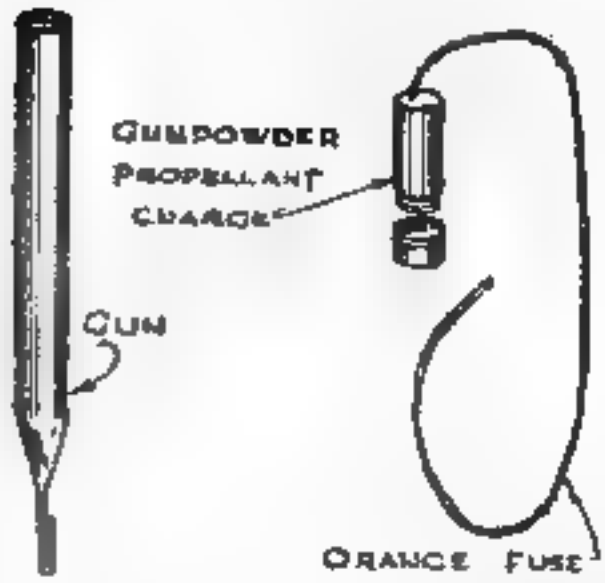
The igniter used is the BZE, which is a friction, time delay igniter. Several colors of knobs are used, and the following are their delays.

Blue	4 1/2	seconds.
Yellow	7	seconds.
Red	1	second.
Gray	Instant ANZ .39 igniter.	

To operate grenade, unscrew knob, on which a cord or wire is attached. Give a pull and throw.



SHRAPNEL GUN.



SHRAPNEL GUN.

This booby-trap consists of a shot-gun discharging shrapnel, which is propelled by a black powder charge. The firing device is orange fuse ignited by a percussion igniter, actuated by means of a trip-wire.

The weapon is capable of propelling the shrapnel at high velocity for a distance of about 50 yards.

Preparation of booby-trap.

(a) Examine the propellant charge, making sure that the orange fuse is firmly secured in metal container.

(b) Examine the igniter to see that the pin is pushed well home and the ends of the pin opened out.

(c) Decide on the alignment of the gun. The charge has considerable lateral spread at distances beyond 25 yards. This must be given consideration in deciding safety zones.

(d) Drive in the near angle-iron recoil picket on the required line of discharge;

(e) Place the empty barrel in position and drive in two front pickets.

(f) Align and drive in the pegs to carry the trip-wire. The trip wire must be on the line of the required discharge of direction.

(g) Secure the trip-wire to the end peg, unreel the wire and run it out to the gun position, temporarily securing it to one of the front recoil pickets, making use of natural supports, shrubs, bushes, boulders, etc., to keep the trip-wire clear of the ground.

Loading the gun.

(a) Lower the metal charge container into the barrel, making sure that the orange fuse lies snugly against the inner side of the barrel. The end of the orange fuse should project and be bent clear of the muzzle.

(b) Ram a ball of paper down the barrel with a suitable ram-rod, taking care not to discharge or damage the orange fuse. The wad acts as a gas check and also holds the metal charge container in position.

(c) Pour in the shrapnel filling. This should extend about 12" along the barrel from the lower wad. Also ram another wad of paper on top of the shrapnel.

Do not at this stage connect the igniter.

(d) Place the loaded gun in position. The closed end of the barrel should fit snugly against the angle-iron picket, muzzle end of the gun between the two front pickets.

(e) Arrange the gun to give an elevation angle of approximately 5°.

(f) Check the alignment.

(g) Secure gun in position by binding the two front pickets together over and under the barrel.

(h) Check again for alignment and adjust as required.

(i) Connecting up. Work behind the gun.

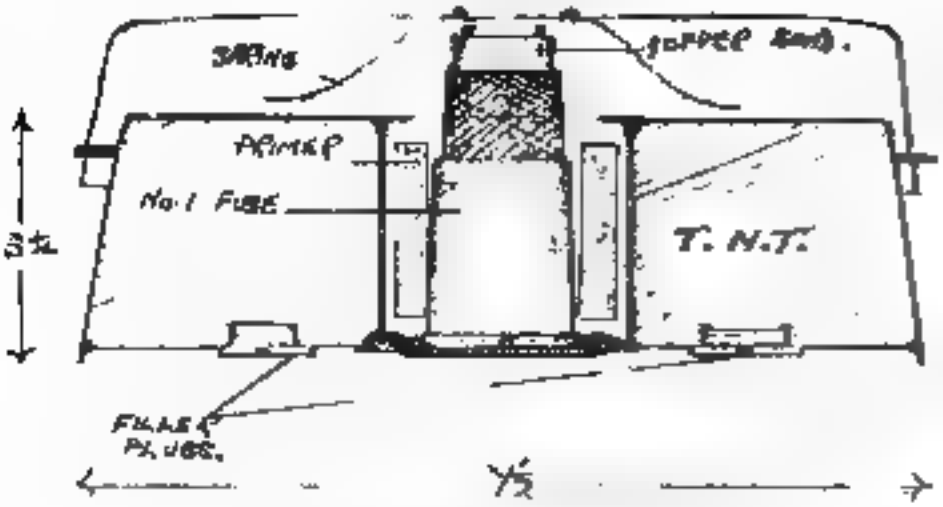
Bind the percussion igniter in position. This must be arranged so that the pull on the pin is in line with the pin's length, as there must be no tendency for the pin to bend, whilst being withdrawn.

The igniter should be secured to one of the front pickets. Connect the trip-wire to the pin of the igniter, adjust its tension so that the pull is insufficient to withdraw the pin. Cut off a half inch from the exposed end of the orange fuse and conceal the gun.

Insert the orange fuse into the snout of the igniter and crimp into position. Seal off all gas escapes with luting. Close the end of the split-pin, and push the pin across the head of the igniter.

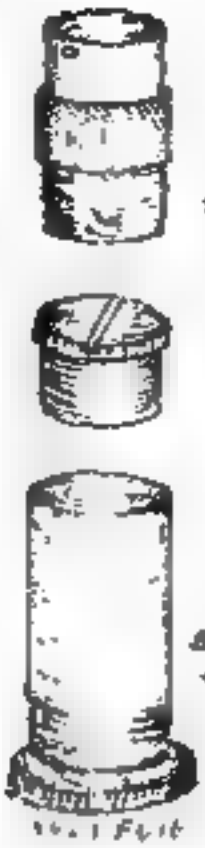
(j) The booby-trap is now set. Leave the site by passing behind the closed end of the barrel.

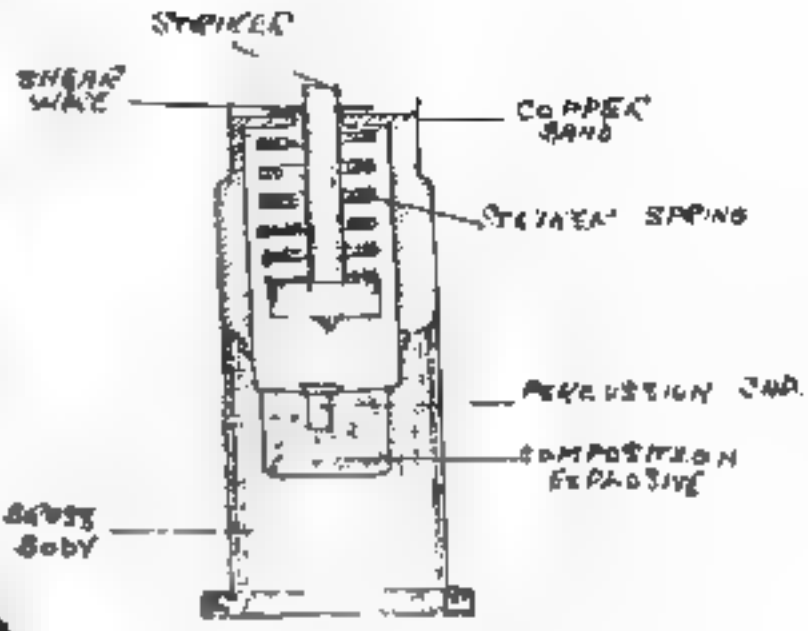
(k) Make all final adjustments from behind the muzzle of the gun.



SECTION.

RECOGNITION DIAGRAM.





BRITISH No. 1. FUSE.

G. S. MK. II A/TK. MINE. No. 1 FUSE.

GS MK II A/TK MINE No. 1 FUSE

Total weight of mine 8 1/3 lb.

Explosive filling 4 lbs. TNT or Baratol.

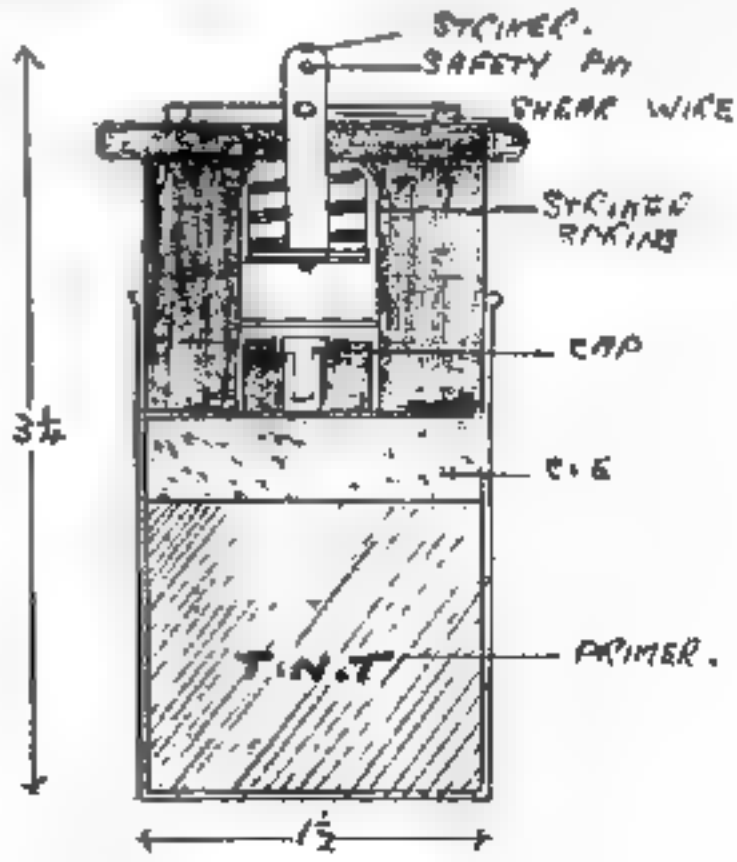
Minimum Safe Spacing with Sarbo rings 2 yards; without, 5 yards. Rings are not used now.

Can be submerged in water for 48 hours. 90% waterproof. Two types of fuses are used, British and S.A. Patterson, in 2 parts. British type has no shear pin, so must be disposed of.

Arming. (A) Lay mine in prepared hole. Unscrew base plug and leave underneath mine. (B) Screw No. 1 fuse in finger-tight. (C) Cover and camouflage.

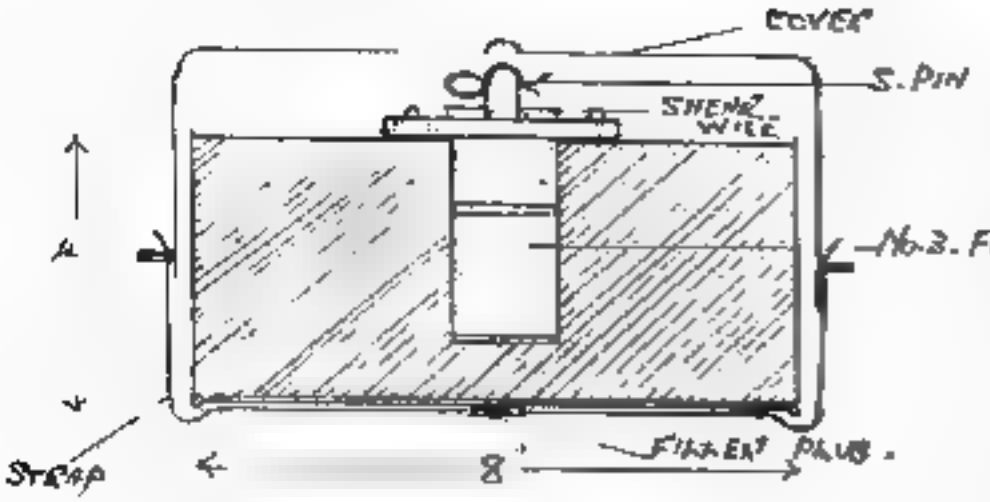
Disarm. (A) Turn mine on its side. (B) Unscrew No. 1 fuse and lift mine.

No. 3. Fuse.



No. 3. Fuse.

NEXT PAGE



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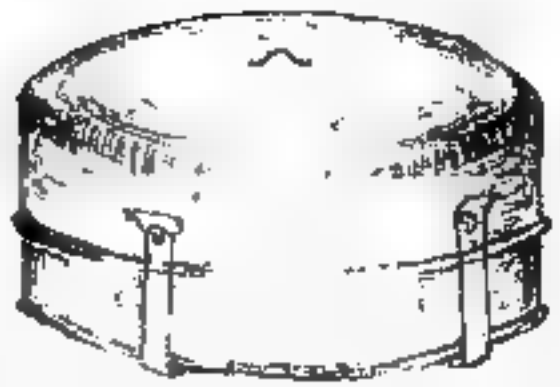


RECOGNITION DIAGRAM.

G.S. MK IV A/TK. MINE. No. 3. FUSE.

GS MK IV ANTITANK MINE No. 3 FUSE

Total weight of mine 12 lbs. 8"x4"

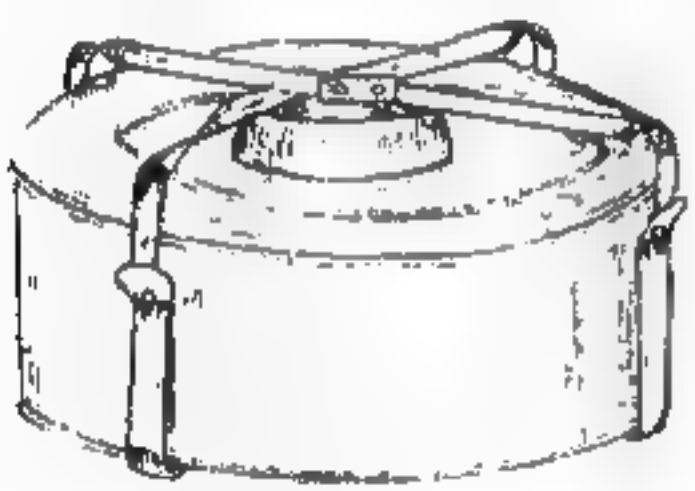
Explosive Filling 8 1/2 lbs. TNT or Baratol.

Minimum safe spacing 5 yards.

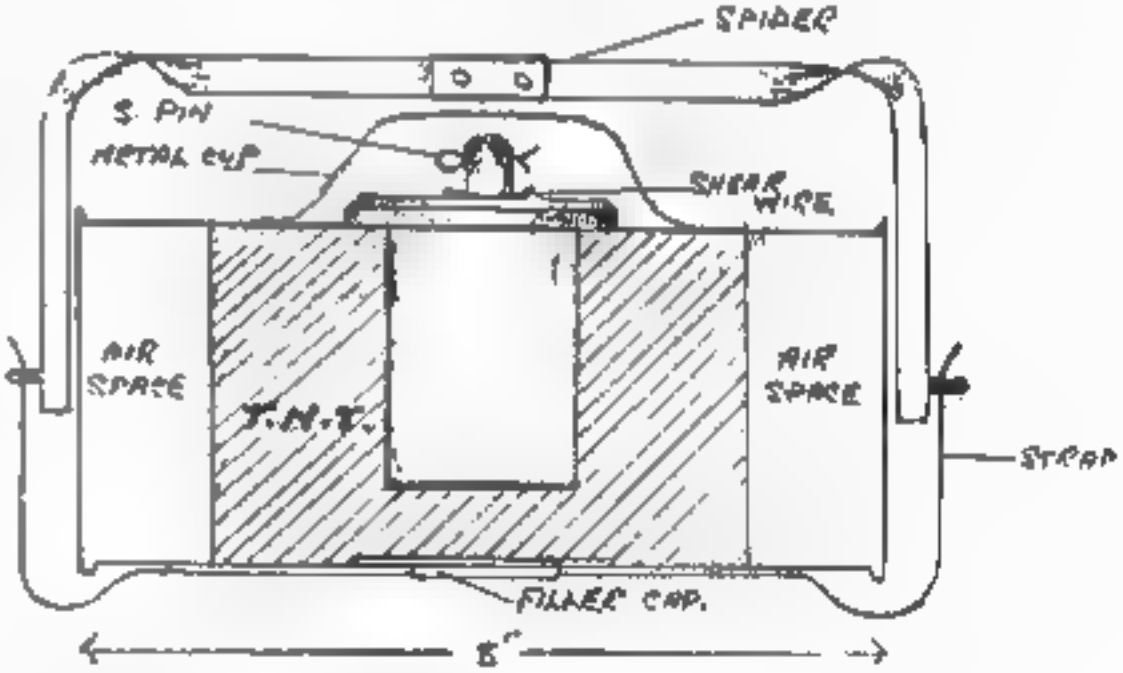
Arming. Lay mine in prepared hole with lid removed. Examine brass shear wire of No. 3 Fuse. If damaged, reject. Remove safety pin at arms length and leave on top of mine body.

Insert No. 3 fuse in mine body. Do not force. Replace lid, cover and camouflage.

Disarm. Remove lid very carefully. Examine shear wire and insert safety pin. Remove No. 3 fuse from mine. Lift mine and stack with fuses separated.



RECOGNITION DIAGRAM.



SECTION.

G.S. MK V A/TK. MINE

No. 3. FUSE.

GS MK V ANTITANK MINE No. 3 FUSE

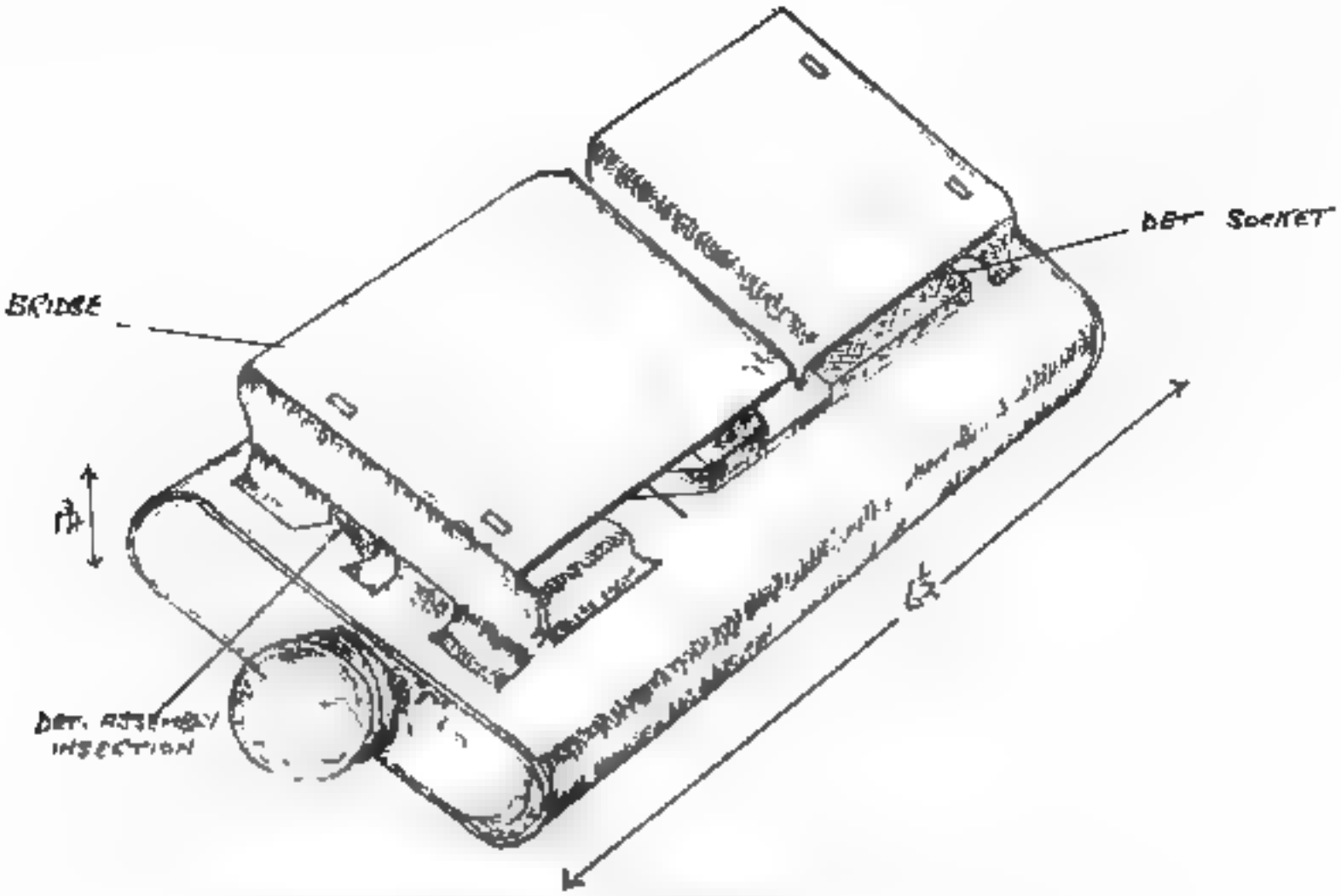
Total weight of mine 8 lbs. (with spider) 8"x4" (body). Explosive filling 4 1/2 lbs. TNT or Baratol. Minimum safe spacing, 2 yards.

Arming. Remove spider, metal cup and washer as with the MK V. Examine shear wire of fuse and withdraw safety pin at arms length and leave on top of mine body.

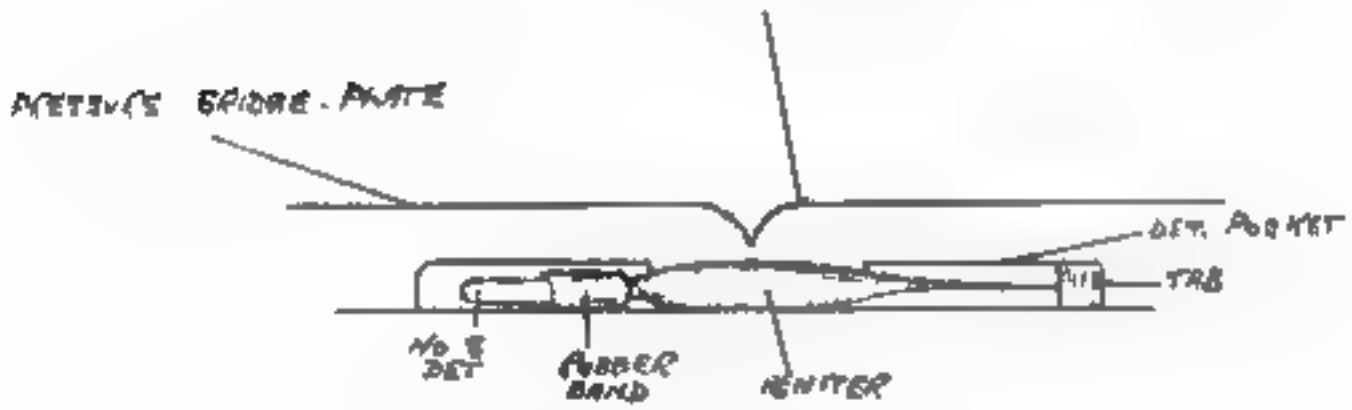
Place No. 3 fuse in mine. Replace metal cup, washer and spider. Engage studs in slots, cover and camouflage.

Disarming. Remove spider, metal cup and washer. Inspect shear wire and insert safety pin. Remove No. 3 fuse from mine. Lift mine and stack seperate from fuses.

N.B. Made with air space. Less explosive than MK IV.



RECOGNITION DIAGRAM.



PART SECTION.

HAWKINS MINE No. 75 & 75A. AND GRENADE.

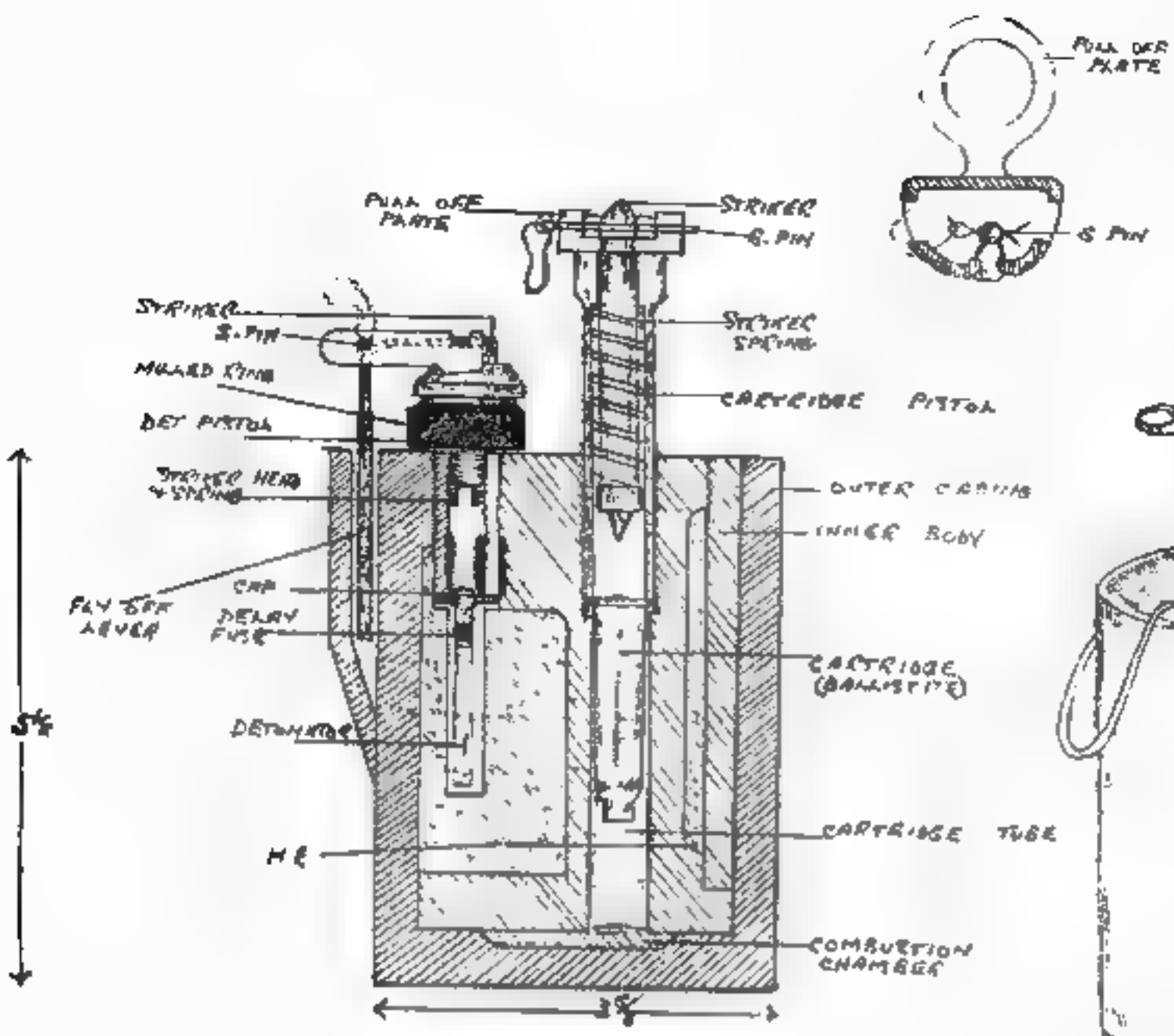
IGNITER & DET. No. 8.

HAWKINS MINE No. 75 & 75A and GRENADE. IGNITER & DET. No. 8.

Total weight of mine 2 3/4 lbs. Explosive filling 1 1/4 lbs. Gelignite. Minimum safe spacing. Mines are laid at a density of one yard.

Arming. Insert open end of detonator in open end of mineigniter and fix with rubber sleeve. Insert 2 prepared igniters, detonators first, into slots so that red end of igniter comes under V of pressure plate. Bend over metal tabs.

Disarming. Bend back the metal tabs. Tilt the mine and slide out the 2 prepared igniters. Note. Never force, if igniters and detonators get stuck. In that case, destroy the mine.



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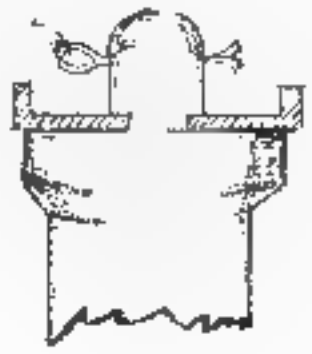
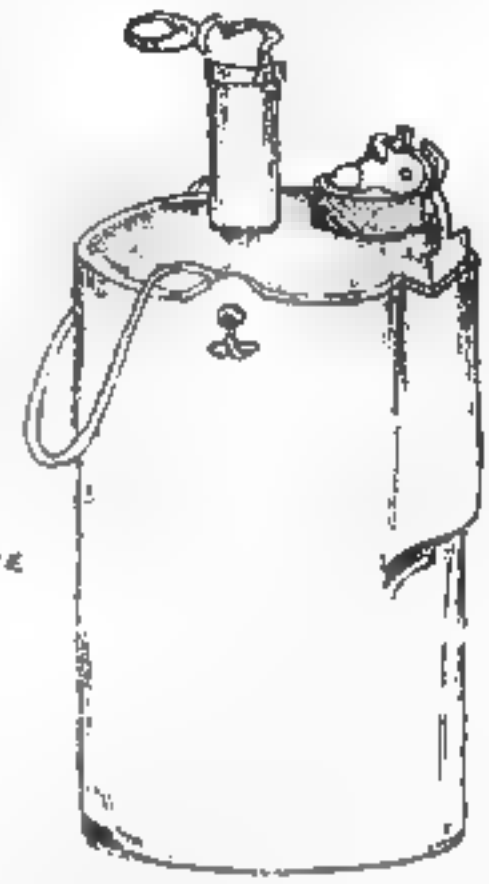


CARTRIDGE PISTOL



RECOGNITION DIAGRAM.

BRITISH STANDARD SHRAPNEL MINE, MK I & II

BRITISH STANDARD SHRAPNEL MINE MK I & II

Total weight of mine 8 lbs. Filling. Amatol 40/60. 40% Amatol and 60% ammonium nitrate and 60% TNT.

Arming. Operation by trip-wire. Prepare safety pin for easy withdrawal. Remove cartridge pistol and drop in Ballistite cartridge, cap upwards.

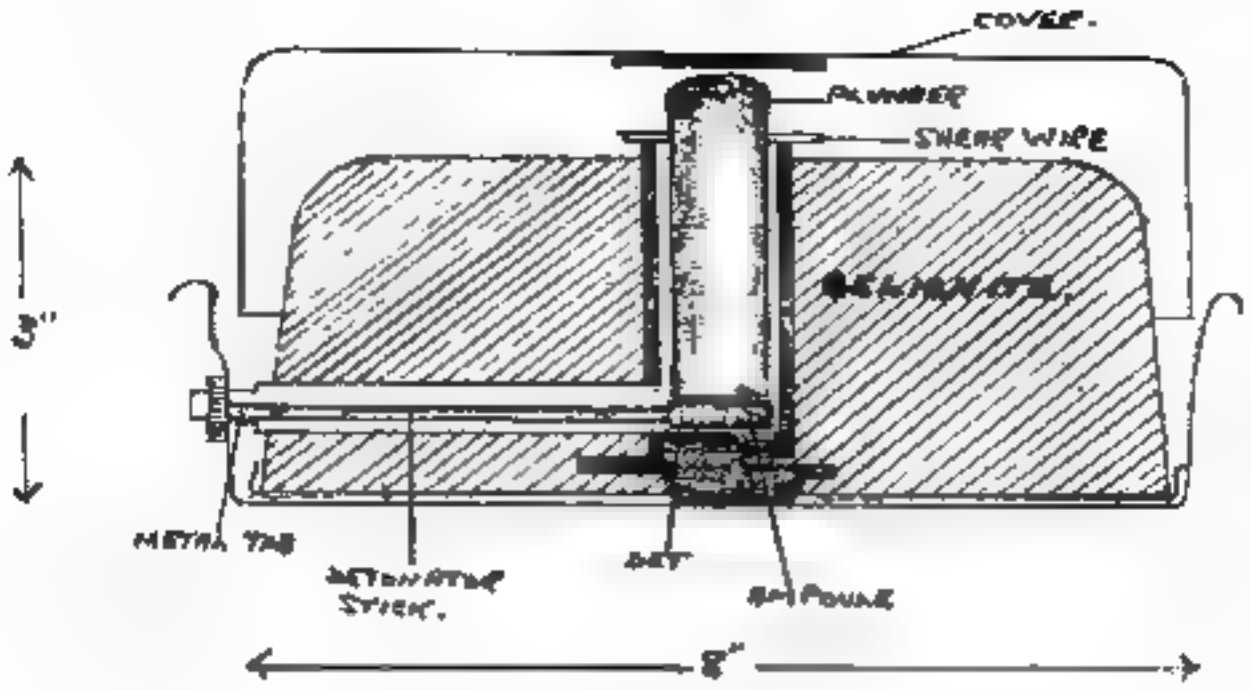
Replace cartridge pistol. Push pin in as far as it will go. Tighten with a spanner. Check safety pin of detonator pistol and remove pistol. Drop in capped detonator cap, cap upwards and replace pistol. Prepare hole so that pull at plate is aboveground. Place mine in hole and secure with pegs. Set up trip-wire. Lay out safety cord from both pins in pistols. Remove safety pin from cartridge pistol and detonator.

Disarming. Place safety pin in cartridge pistol and detonator. Disconnect trip-wire and lift mine. Remove detonator and cartridge pistols, tip out cartridge and capped detonator.

Note. Filling marked on green band. (Red band, normal filling HE, Red crosses, tropical filling. Red cross and dashes, tropical filling for limited period only.

MK II

Same as MK I, but has longer detonator handle extending to length of outer cannister, wire handle and safety delay fuse under cap.



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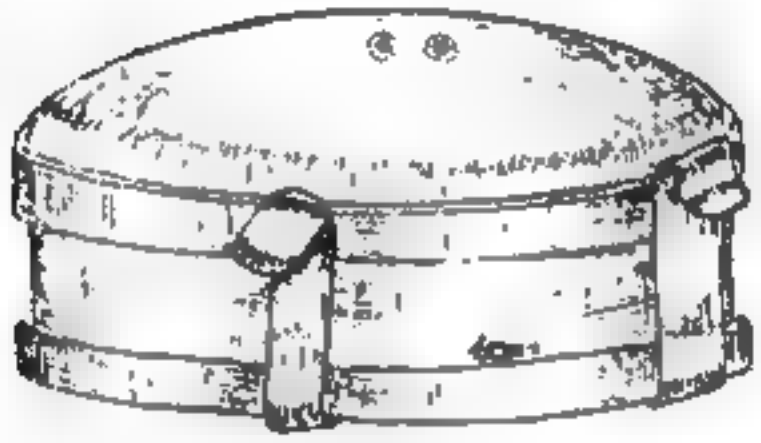


RECOGNITION DIAGRAM.

E.P. MK II A/TK. MINE DETONATOR & AMPOULE.

EP MK II ANTITANK MINE. DETONATOR & AMPULE.

Total weight of mine 7 lbs. Filling 4 1/4 lbs. Gelignite or TNT. Minimum safe spacing 5 yards.

Testing. Withdraw steel rod and press firmly on cover to ensure that shear-wire is in order. Insert brass testing rod and push home. If rod cannot be fully inserted, reject mine. Withdraw brass rod, replace steel rod and secure.

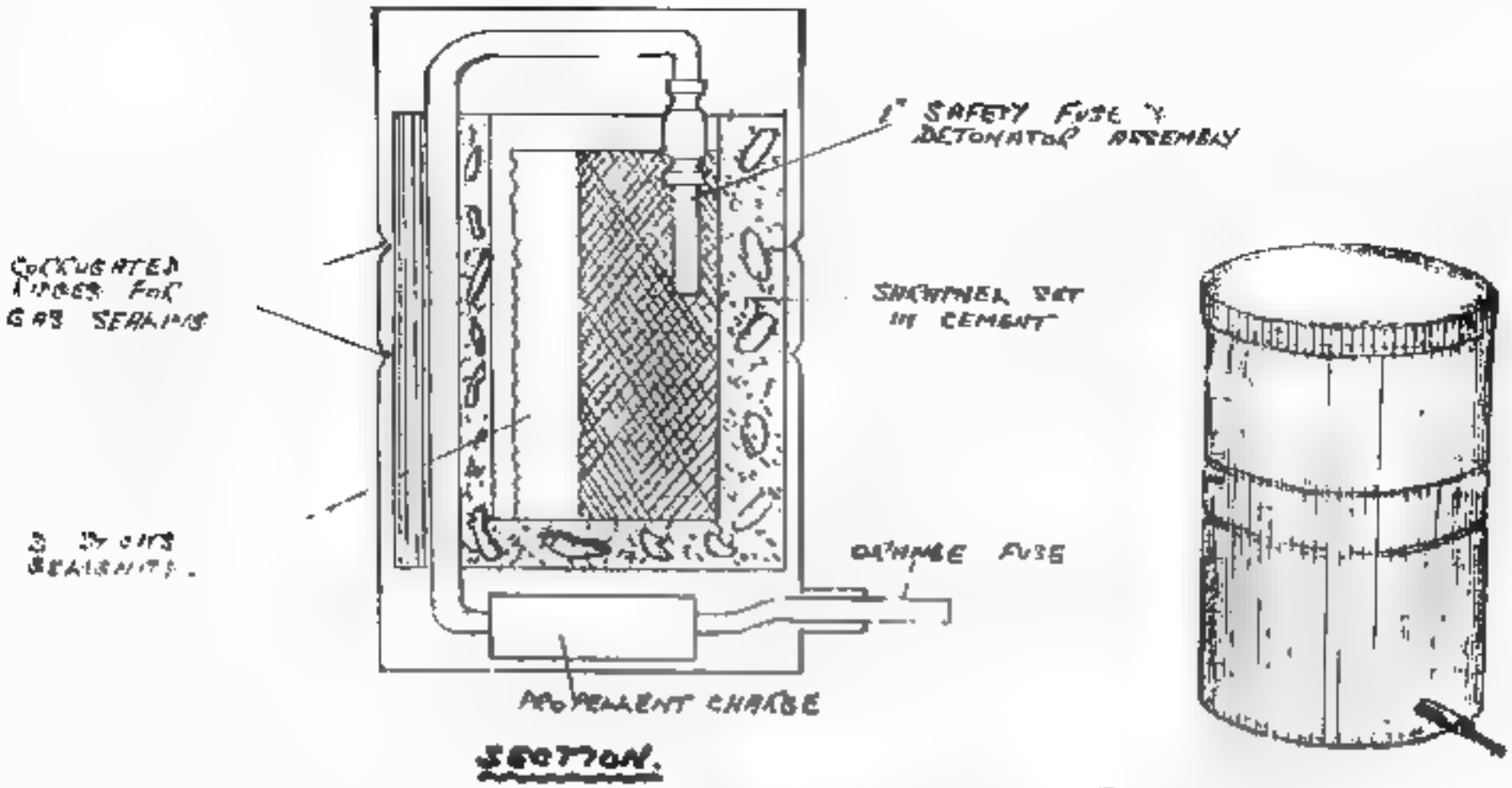
Arming. Place ampule, red end first, into open end of detonator and seal with luting (axel grease). Lay mine and stick beside each mine hole.

Withdraw steel rod. Insert detonator stick to its full length. Do not force, and secure with metal tabs. Cover and camouflage.

Disarming. These mines should never be disarmed unless absolutely necessary.

Carefully withdraw detonator. If stuck, do not force. To be destroyed. If necessary to remove, attach cable and pull clear. Transport by hand only. If mine has been in ground for 2 months must not be transported even if disarmed nor must they be stacked on top of each other. Can be laid to a minimum space of 2 yards.

Very much affected by climatic conditions owing to its Gelignite filling. It will become very dangerous to handle if laid for any length of time.



EP No. 4 ANTI-PERSONNEL MINE.

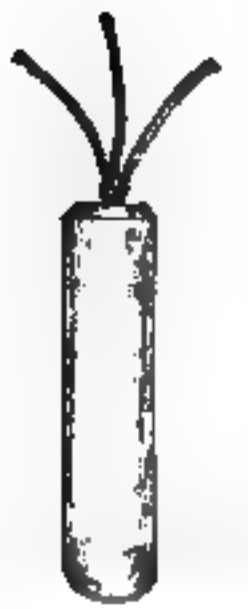
Filling. Gelignite.

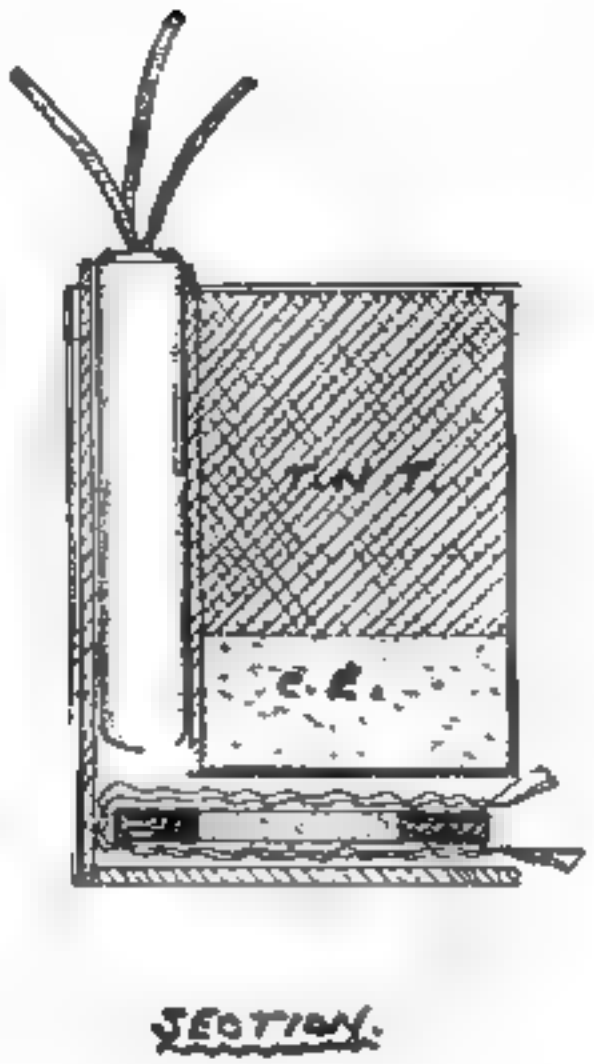
This is an anti-personnel mine, normally operated by a switch, pressure EP No. 1, although it may be operated by any British switch. When the mine is fired, the cylinder containing shrapnel is lifted clear of the ground and then bursts.

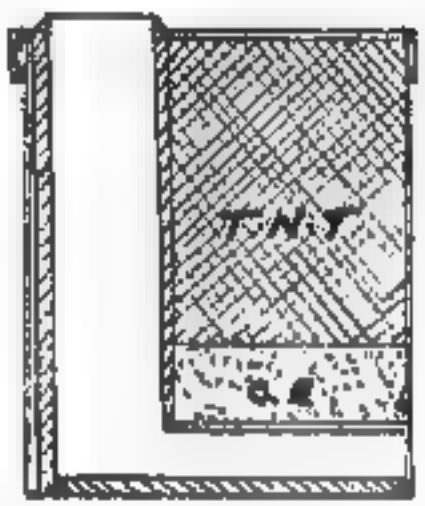
Laying. (a) Dig a hole for the mine and switch. (b) Remove the lid from the mine, withdraw the inner cylinder and take out the fuse unit. (c) Thread the detonator end of the fuse through the tube, commencing at the lower end of the cylinder. Thread the other end of the orange fuse through the hole in the bottom of the container, from inside to outside. Draw through, lower the inner cylinder gently into the container at the same time. Make sure that the inner cylinder is fully down into the container, and the powder charge is comfortably between the two "distance pieces" at the bottom of the inner cylinder. (c) Connect the orange fuse to the switch being used. (e) Insert three sticks of Gelignite into inner cylinder. The stick remote from the fuse tube is prepared for the detonator, and the detonator pressed gently home. Replace the lid of the mine and seal with luting. (f) Cover the mine and the switch.

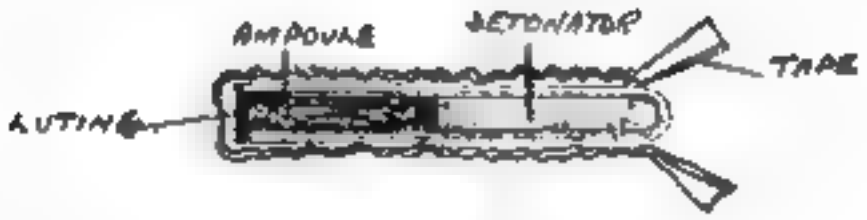
EP SWITCH No. 1.

This is a tinplate device with a metal cylinder into which the igniter ampule can be inserted. The switch is enclosed in a cardboard cover to prevent ingress of sand, etc., which would prevent its operating. It is designed so that, when trodden on, the ampule will crush and set off the mine.









E. P. No. 5. A/P. MINE.

DETONATOR No. 8. & AMPOULE.

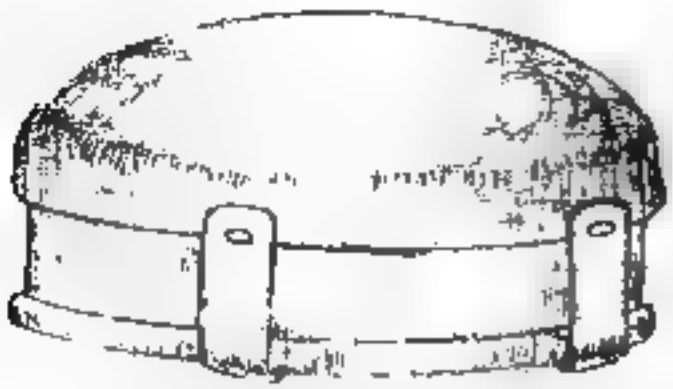
EP No. 5 ANTI PERSONNEL MINE. DETONATOR No. 8 & AMPULE.

Weight of mine 8 oz. Explosive filling Gelignite or TNT. Main filling 1 1/2 oz. CB and a five oz. layer of TNT.

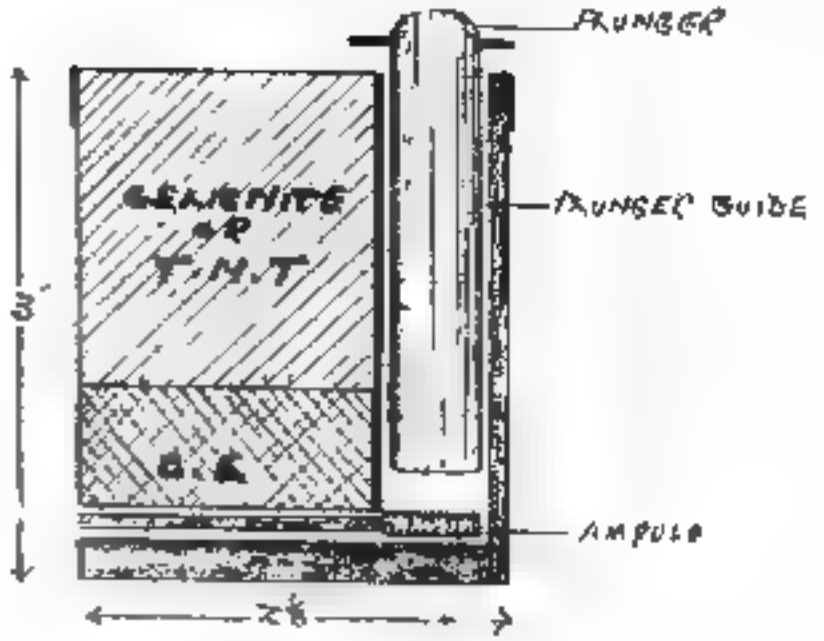
Arming. Prepare hole and examine plunger for fit in cannister. If OK, grease. Insert ampule, red end first into open end of detonator and seal flush with luting. Examine the hole at the side of the exploder to insure that it is clear. Wrap tape around detonator. Insert tape and detonator gently into exploder, open end first and smear with luting.

Place the exploder in the prepared hole and pack earth around the sides with earth to support it, leaving the top clear. Insert the selected plunger, complete with "prongs" gently into plunger guide and lower slowly until it is resting on the detonator.

Disarming. Destroy in site if possible, otherwise, gently uncover and lift mine out. Lay aside for destruction.

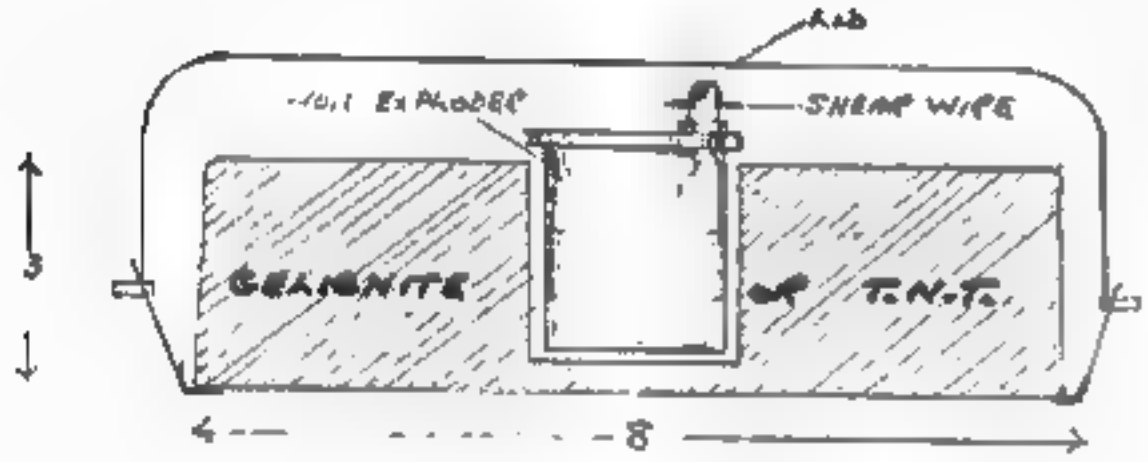


RECOGNITION.



SECTION.

No. 1. EXPLODER



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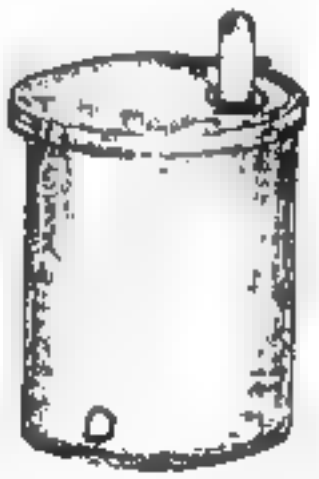


RECOGNITION.

E. P. MK V A/TK. MINE.

AMPOULE & No 8. DET. No. 1. EXPLODER.

LP MK V ANTITANK MINE. AMPULE & No. 8 DETONATOR. No. 1 EXPLODER.

Total weight of mine 9 1/2 lbs. Filling. 4 1/2 lbs. of Gelignite or 6 1/2 lbs. of TNT.

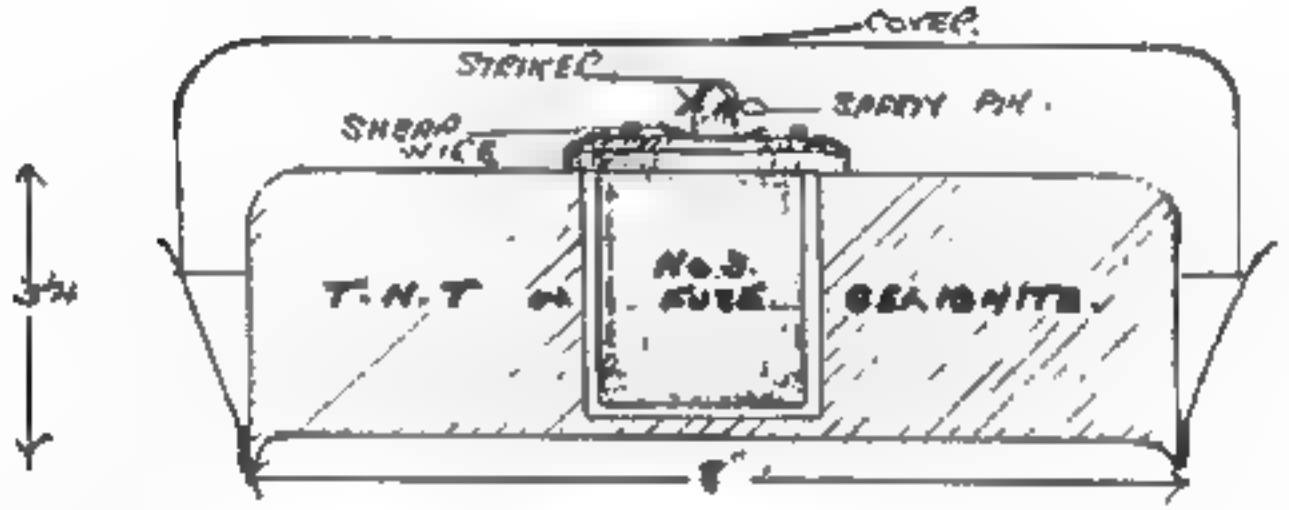
Testing. Examine No. 1 exploder for oily exudation or outside rust. Examine plunger for damage to shear wire. Smear upper portion of plunger with grease and insert in plunger guide. Test for clearance with No. 8 detonator. Remove cover of mine and straighten straps. Examine exploder packet for oily exudation. Test lid for fit. Should not be resting on plunger.

Arming. Insert ampule, red end first, into open end of detonator and seal end flush with luting. Place exploder on inverted mine cover, free from grit. Insert ampule and detonator, with sleeve in position and seal end with luting.

Lay mine in prepared hole, replacing cover. Do not force or press on lid.

Disarming. Gently remove cover of mine. Carefully remove No. 1 exploder. Disarm same if in good condition, by taking out plunger. If showing signs of deterioration, destroy on site.

RECOGNITION.



SECTION.

E.P. MK VI A/TK. MINE.

No. 3. Fuse.

EP MK VI ANTITANK MINE. No. 3 DETONATOR

Weight of mine 8 lbs to 9 1/2 lbs., (Approximately). Filling 4 lbs. Gelignite or 6 1/2 lbs. TNT. Minimum safe spacing 2 yards. Testing. Remove cover and straighten straps. Insert No. 3 fuse. Remove safety pin from fuse at arms length. Insert fuse and leave safety pin in and test for fit. Test for fit of lid and pressure on top of fuse. Remove fuse and replace cover.

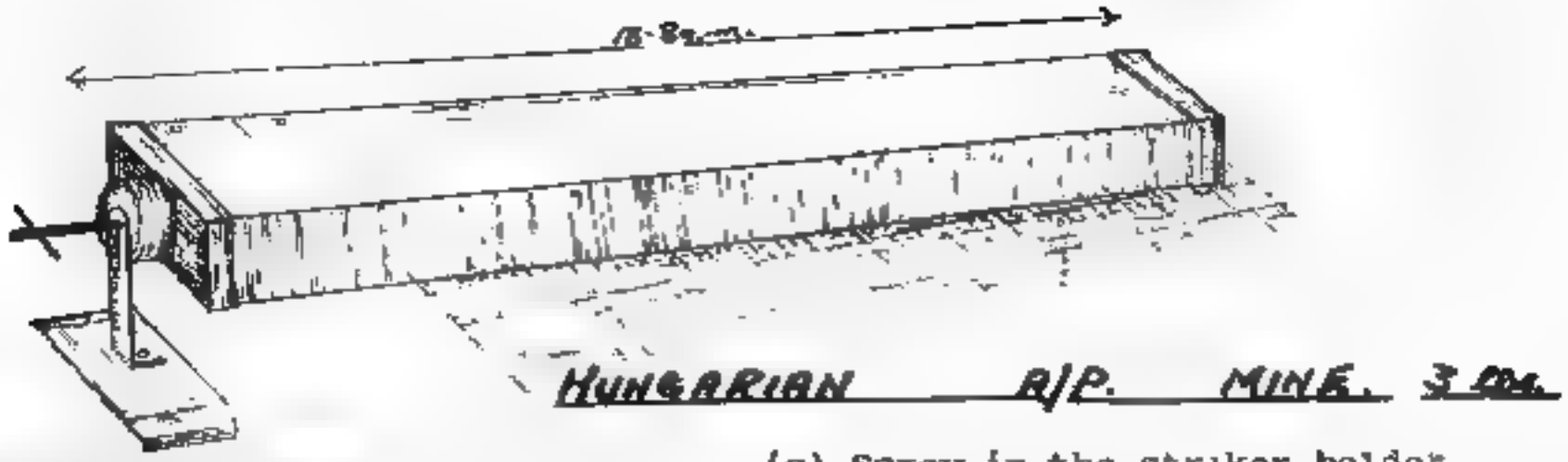
Arming. Remove cover. Examine shear-wire of No. 3 fuse. Remove safety pin from fuse at arms length. Insert fuse and leave safety pin on top of mine body. Replace lid by hinging, as with MK V.

Disarming. Remove cover, undo one strap and hinge off. Inspect shear-wire of No. 3 fuse. Remove fuse and insert safety pin at arms length.

Note. Stack mines and fuses separately.

EP MK VII ANTITANK MINE.

This mine looks the same as the MK VI with seamless sides and recessed base. But instead of No. 3 fuse it has the same exploder as used in the MK V, i.e., detonator & ampule complete with plunger and exploder No. 2.



HUNGARIAN ANTI-PERSONNEL MINE.

Weight 3 lbs.

This is a very sensitive anti-personnel mine which may be operated by as small a pressure as 7 lbs. It consists of a rectangular tube of metal, one end of which carries the striker mechanism.

The mine usually lies in an inclined position with the striker at the highest end. A brass tongue on the operating device is inserted in one of the holes in the striker. A small downward movement of the mine releases the striker and so fires the mine.

To prepare the mine.

(a) Pull out the striker by means of the cross-piece and put a safety-pin or wire into the first hole of the striker.

(b) Unscrew the striker holder and insert detonator with cap.

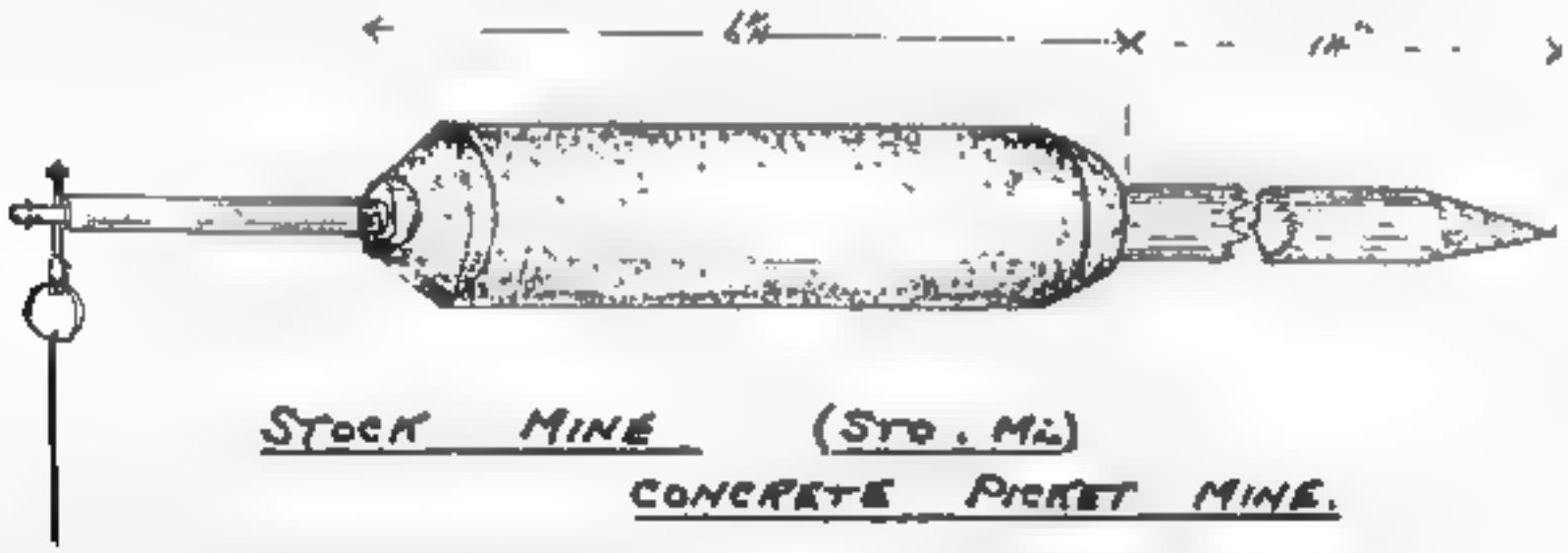
(c) Screw in the striker holder.

(d) Slip the operating device over the striker and pull out the latter until the tongue can be inserted in the second hole in the striker.

To arm the mine. Withdraw the safety-pin from the outer hole in the striker.

To disarm. Hold the operating device firmly in position and insert a wire in the outer hole in the striker. If the mine is found set with the tongue in the outer hole of the striker, ram a thin piece of wood through the operating device, so that the wood jams on the striker holder and prevents the tongue from moving.

To lift mine. Attach from one end, 50 yards of cable and pullclear, from under cover.



STOCK MINE CONCRETE PICKET MINE.

The body of the mine is made of concrete containing metal loading. Within the body is a 100 gram charge fitted either end with a standard igniter 22.42, 22.35 or a modified 2u22.35, the latter being operated by the withdrawal of the safety-pin. It can be recognized by the absence of the hole which is generally used for taut tension wire. A 15 inch wooden peg is driven into the ground and the mine is laid with the concrete portion above the ground. The mine operates with the 22.35 with which a trip-wire is attached over a suitable object or picket driven into the ground near the mine.

To prepare the mine.

(a) Insert detonator into prepared charge.

(b) Push the charge into the base of the concrete case.

(c) Screw igniter into charge.

(d) Push in the wooden picket.

Arming.

(a) Attach a trip-wire to the igniter and lay out the wire to a suitably supported portion over the ground.

(b) Attach far end of trip-wire to a suitable object fixed firmly in the ground.

(c) Remove safety device.

NEXT PAGE

Disarming.

a Identify the igniter and neutralize it.

b, Cut trip-wire

The modified igniter 2u 22.35 can be neutralized by passing a wire or cord through the ring in the safety pin and bind it around the head of the igniter.

To lift mine. Attach 50 yards of cable and pull clear, from under cover.

SKI MINE. A/SKI or A/SLEDGE. A/P.

SKI MINE, ANTI-SKI OR ANTI SLEDGE A/P.

This was orifinally intended as an anti-ski or anti-sledge mine. But it may be equall used as an anti-personnel mine in cultivated ground.

It consists of a prepared charge of 100 grams, inserted in a thin metal tube having a wooden picket about 12 inches long in the base. The mine is fitted with an ordinary three-prong "S" mine igniter.

To prepare mine.

(a) Insert detonator into prepared charge and screw in the igniter.

(b) Unscrew the nut on the safety-pin.

To arm the mine.

Withdraw the safety-pin by means of the cord attached to the ring in the pin.

To neutralize the mine.

Insert a nail or wire into the safety pin hole in the igniter and bend around to prevent from falling out.

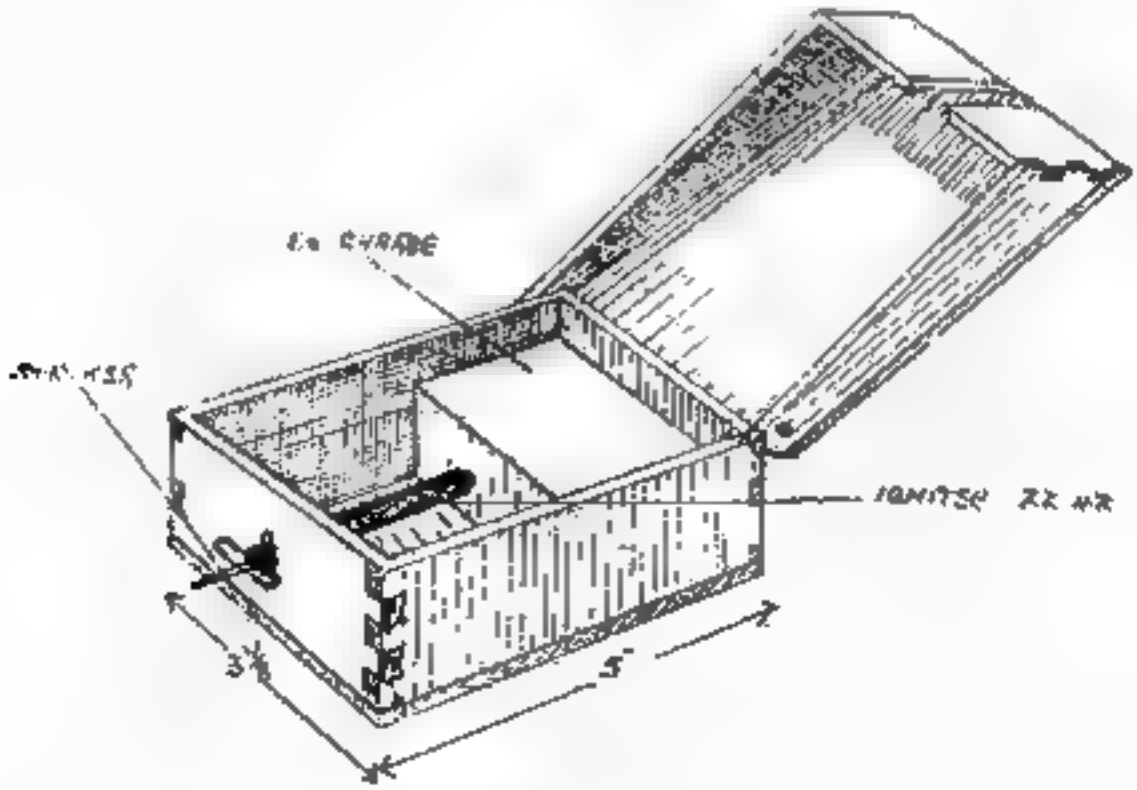
To lift the mine.

Attach 50 yards of cord or cable to the hole in the body of the mine and pull, from under cover.

Note. See Schü mine (next).

The actuating pin in the igniter is specially designed to include an eye to which a cord may be attached.

In any mine using this igniter, particular search must be made for such a cord. If found, this should be cut without exertion or pull. There may be a pull-igniter and prepared charge at the other end of the pull-cord. If present, this too should be neutralized.



SCHÜ MINE MK.

SCHÜ MINE 42.

This mine is a dovetailed wooden box with a hinged lid. It contains a single block charge of 200 grams of explosive. It is operated by a 22.42 igniter.

The igniter screws into the block charge and is inserted through a hole in the side of the box. The striker and the actuating-pin holding the striker pro-

trudes through the hole in such a way that the recessed lid can bear on the actuating-pin. Pressure on the lid may then push out the pin and operate the mine.

To prepare the mine.

(a) Unscrew protecting cap from igniter.

(b) Insert a detonator in charge, open and outwards.

(c) Push the igniter through the hole in the mine and screw into prepared charge.

(d) Turn the actuating-pin so that the link is below the striker.

(e) Close the lid carefully.

N.B. The mine should be prepared at the place where it is to be laid. There are no safety devices so when already prepared, it becomes dangerous.

Pressure required; 6 to 11 lbs. to operate the mine.

Arming; as above.

To neutralize the mine.

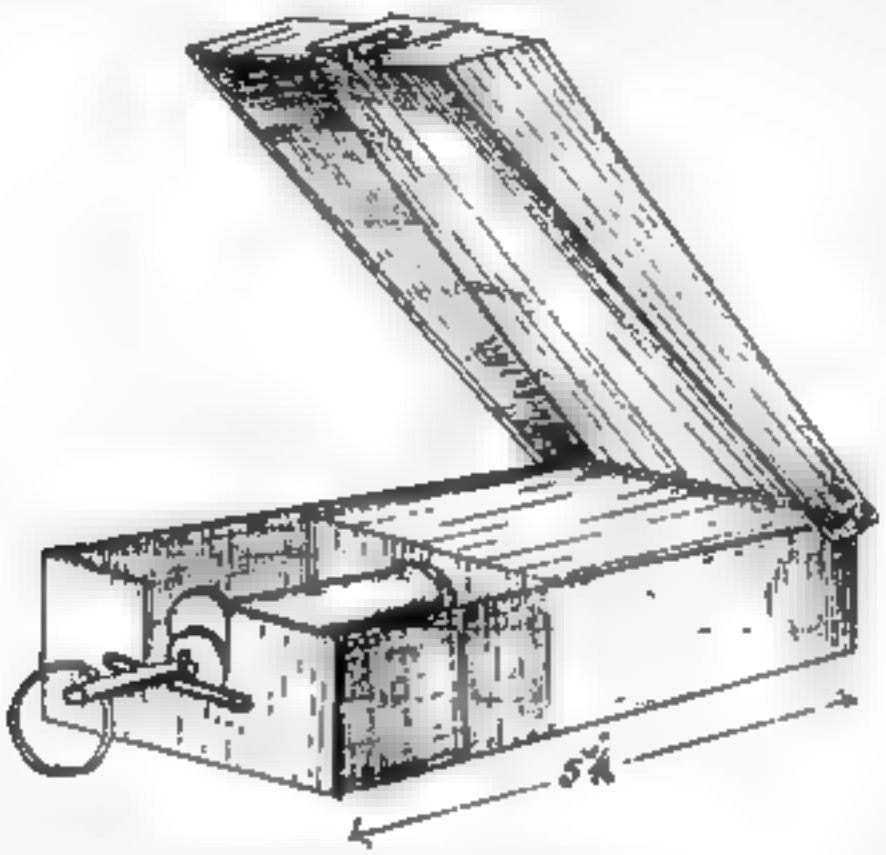
(a) Examine lid and the igniter for booby-trap. If present, neutralize them.

(b) Lift lid carefully and extract igniter.

(c) Unscrew the igniter and remove detonator from charge.

To lift the mine, Attach 50 yards of cable and pull, from under cover.

See special note under "Ski-mine".



1 lb. ANTI-PERSONNEL MINE. (Bakelite)

1 lb. ANTI-PERSONNEL MINE (BAKELITE).

This mine consists of a rectangular box with a wedge-shaped hinge lid. It is made of Bakelite and contains three pieces of deeply grooved metal for fragmentation effect.

The mine operates from pressure on the lid, which causes the latter to descend and push out a specially shaped striker cocking arm.

To prepare the mine.

(a) Using the ring at the end of the striker, cock the latter until the outer hole in the striker is visible and put a safety-pin or wire through this hole.

(b) Unscrew the collar on the end of the striker holder and insert a special detonator through the collar.

(c) Screw in the collar with the detonator in place.

(d) Insert the detonator in the charge and lay the detonator holder so that the flange is inside the box.

(e) Close the lid of the box.

To arm the mine.

(a) Open the lid of the mine.

(b) Pull out the striker until the second hole in it is visible. Insert from the underside, the specially shaped pin.

(c) Close the lid and remove the ring from the end of the striker.

(d) Remove the safety wire from the outer hole in the striker.

To neutralize the mine.

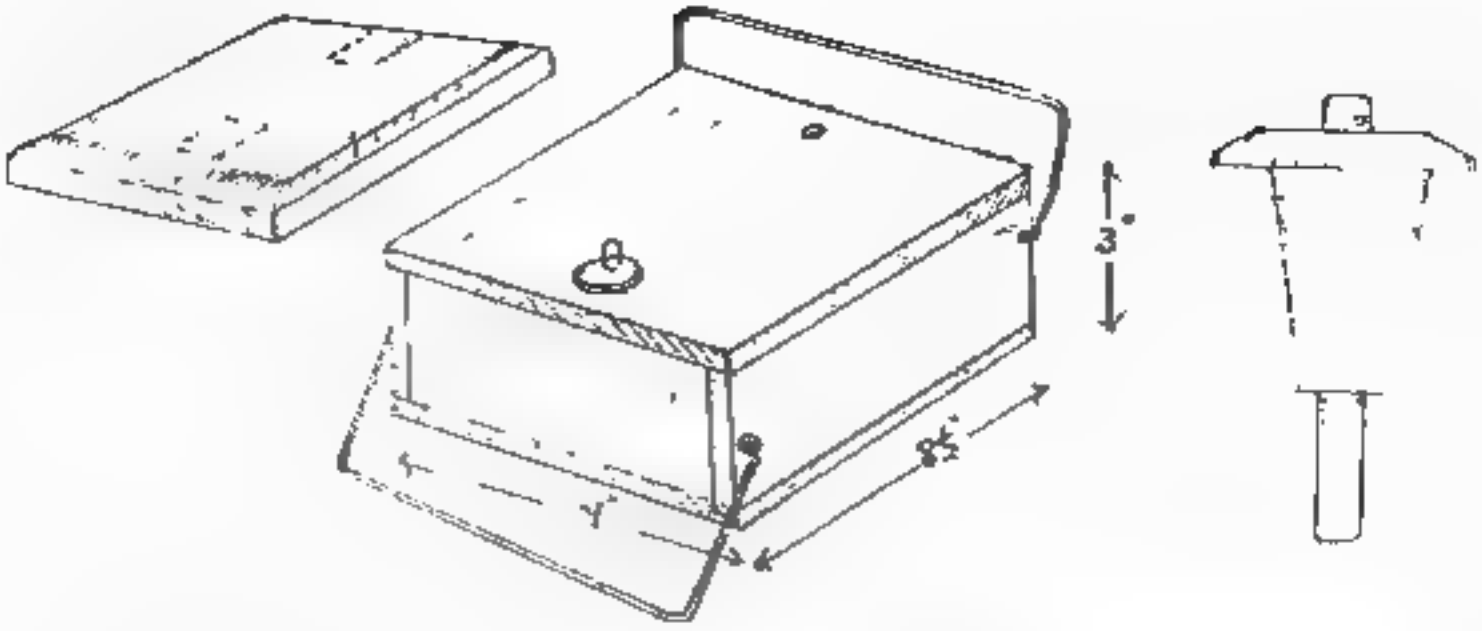
Insert a wire in the hole in the striker nearest the special pin.

To lift the mine.

(a) Neutralize the mine.

(b) Attach 50 yards length of cable to the outermost hole in the striker and pull, from under cover.

(c) Leave the mine and detonator conspicuously marked.



ANTI - TANK MINE 1·8 Kg. (Wooden Box).

ANTI-TANK MINE 1.8 kg. (Wooden Box).

This is an improvised box mine. This false lid has two holes to accommodate two igniters. These are fixed with detonators and operate by the shearing of a wire.

The cover encloses the top of the mine and is prevented from being accidentally separated from the mine by the metal retainers. Two metal plates on the underside of the cover insure the operation of the igniters by the pressure on the mine.

To prepare the mine.

(a) Remove the cover and insert the igniter, complete with detonator, in the holes in the false lid.

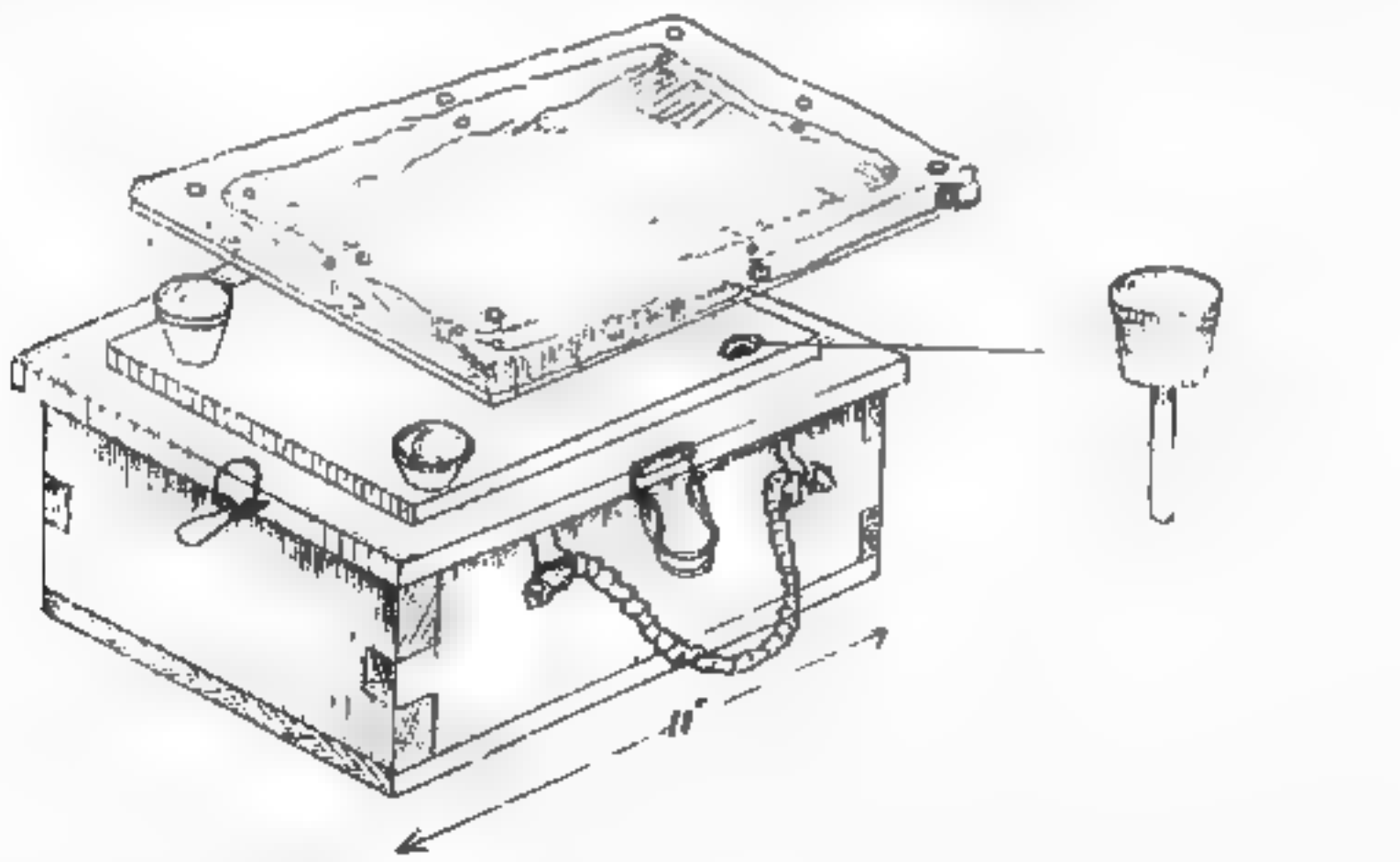
(b) Replace the cover and then put the retainers in position.

To arm the mine.

The mine prepared is armed. There are no safety devices in the igniters.

To lift the mine.

Attach 50 yards of cable to one of the retainers and pull, from under cover.



FOUR IGNITER MINE 14·25 Lbs. (Wooden Box).

FOUR IGNITER MINE 14.25 lbs. (Wooden Box)

This mine contains 5 kg. of explosive. In the false lid are holes near each corner to take four pressure igniters.

The cover consists of a frame and a separate top piece. The latter is glued to canvas, which in turn, is nailed to the sides of the frame.

NEXT PAGE

Two types of Bakelite igniters are used. But the method of handling the mine is the same in either case.

To prepare the mine.

(a) Take out the dummy pegs from the igniter holes and insert the igniters with detonators attached.

(b) Replace the cover and secure by means of the clips.

To arm the mine.

As above. There are no safety devices in these igniters.

To neutralize the mine.

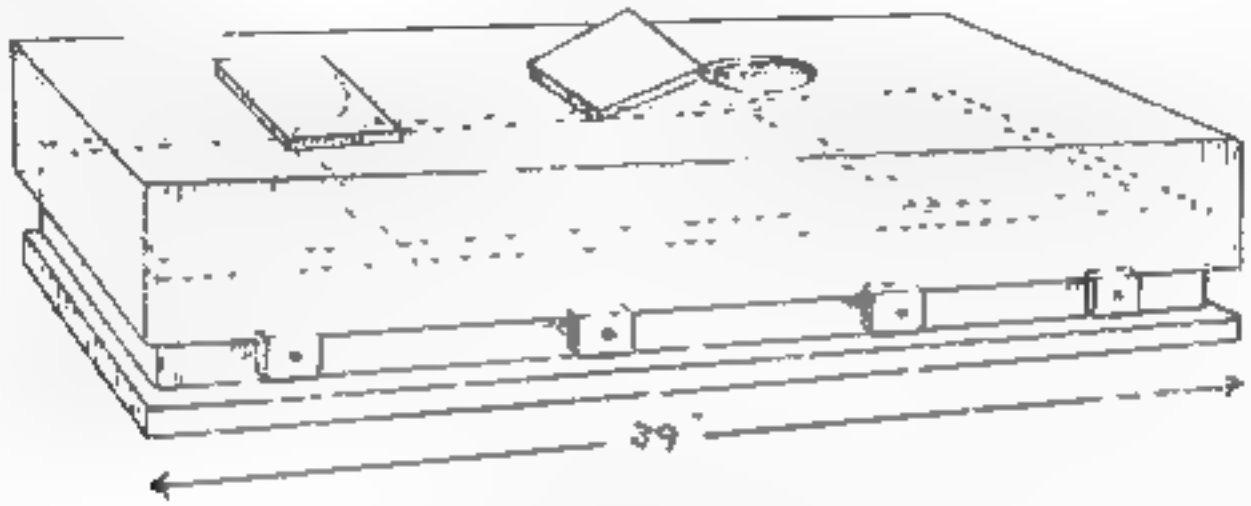
(a) Examine the metal fasteners for booby-traps. If present, identify and neutralize them accordingly.

(b) Remove the cover and take out the four igniters.

(c) Replace cover upside down and leave the igniters in the upturned lid.

To lift the mine.

Attach 50 yards of cable to the rope handle of the mine and pull, from under cover.



ANTI-TANK MINE 4 kg. TYPE 9. (Wooden Box).

ANTI-TANK MINE 4 kg. TYPE 9 (Wooden Box)

This is a long, rectangular box containing two striker mechanisms with a 4 kg. charge of high explosive placed between them. Two movable covers on the lid of the mine give access to the strikers. Between the lid and the protruding base of the box are several thin pieces of wood which must be crushed before the strikers can be fired by the pressure of the lid.

To prepare the mine.

(a) Insure that the wooden shear pieces are in place.

(b) Remove the lid and cock the strikers.

(c) Remove the detonator holders and insert in them the prepared cartridge and detonator.

(d) Replace the lid.

To arm the mine.

As above, the mine is armed.

To neutralize the mine.

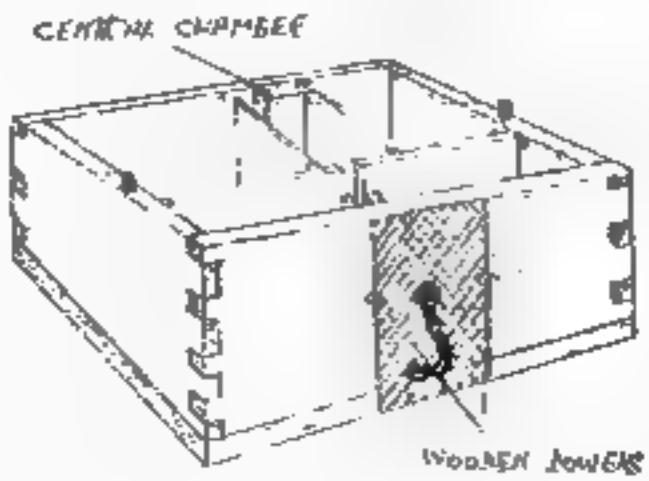
(a) Open the movable cover and push a pen into the slot between the striker and the cartridge holder. A knife blade or similar strip of metal can also be used.

(b) Remove the cartridge holder and take out the cartridge.

(c) Replace the cartridge and leave the lid lying across the mine.

To lift the mine.

As there are no safety devices or easy method of attaching a cord to the mine, it should be neutralized, as above, and conspicuously marked. Inform sappers.



HOLZMINE MK A/TK.

NEXT PAGE

HOLZMINE 42. ANTI-TANK.

This wooden box mine contains 11 lbs. of explosive, either poured or in molded blocks. A pressure block protruding through the lid operates the igniters by pushing out the safety-pin.

The mine functions when a pressure greater than 400 lbs. acting on the pressure block shears two small wooden dowels and allows the pressure block to move downwards and operate the igniters.

To prepare the mine.

(a) Remove the lid.
(b) Take out the pressure block.
(c) Make sure that the shear block is firm, otherwise, discard the mine.
(d) Remove the exploder blocks from the central compartment.
(e) Fit a detonator into the igniter and screw it into the prepared charge.
(f) Replace the exploder charges, making sure that the safety-pin is located under the shear block.
(g) Insert the pressure block with the red surface facing inwards. The pressure block cannot operate the mine in this position.
(h) Replace the lid and secure it with the two hooks.

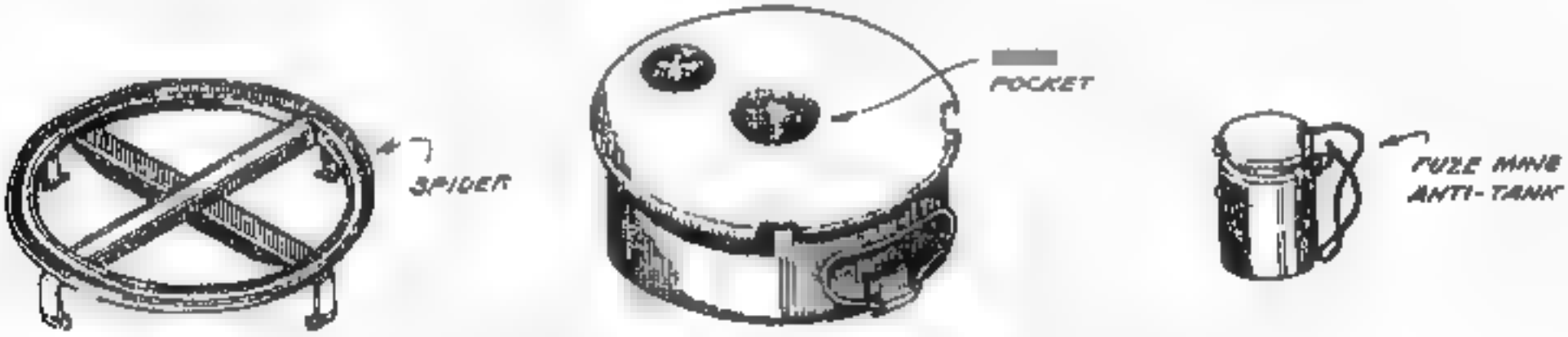
To arm the mine.

(a) Remove the lid and pressure block and reinsert it with the pressure block facing the front of the mine.
(b) Replace the lid and secure it. The red surface on the front of the mine, the mine lid, and the pressure block should now form a continuous band.

To neutralize the bomb.

Remove the lid and pressure block. Replace the lid and insert the pressure block upside-down in the hole in the lid so that it can be easily recognized as neutralized.

This mine may be booby-trapped, with no easy method of attaching a cord. So, therefore, it should be left conspicuously marked for the sappers.



AMERICAN H/TK OR A/P. MINE.

AMERICAN ANTI-TANK OR ANTI-PERSONNEL MINE.

This is a small cylindrical mine containing 5 lbs. of high explosives. It employs a spider to transmit pressure to the fuse. The flanged rim on top of the body is matched in two places for assembling the spider.

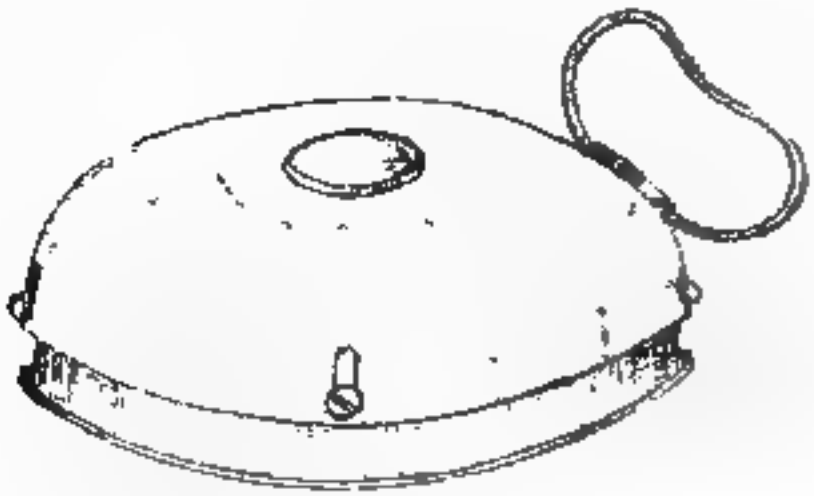
The fuse used with the mine is the MI. AI. fuse which is inserted into the fuse pocket on the top of the mine. On the side of the mine is a carrying handle.

Arming.

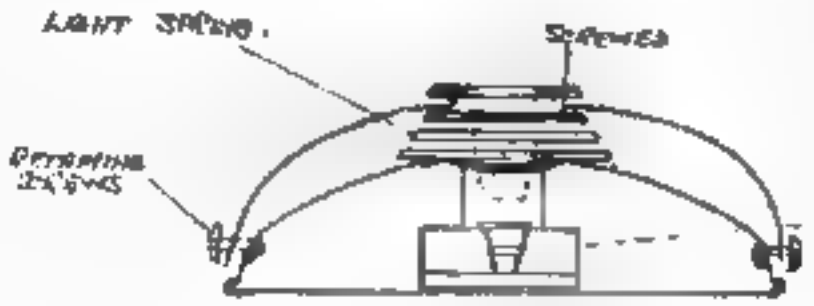
(a) Remove the spider from the bottom of the body.
(b) Insert the fuse and push down until it engages. When this is assembled, the upper surface of the fuse body is flush with the upper surface of the mine.
(c) Assemble the spider by aligning, but not so as to engage two hooks with notches in the flange of the body. Engage the other two hooks over the flange on the body, press the first two hooks through the notches, then rotate the spider to engage the other two hooks.
(d) Withdraw the safety fork and lay it beside the mine.

Disarming.

(a) Replace the safety fork.
(b) Rotate the spider and lift off.
(c) Remove the fuse and repack it in the container.
(d) Replace the spider.



RECOGNITION.



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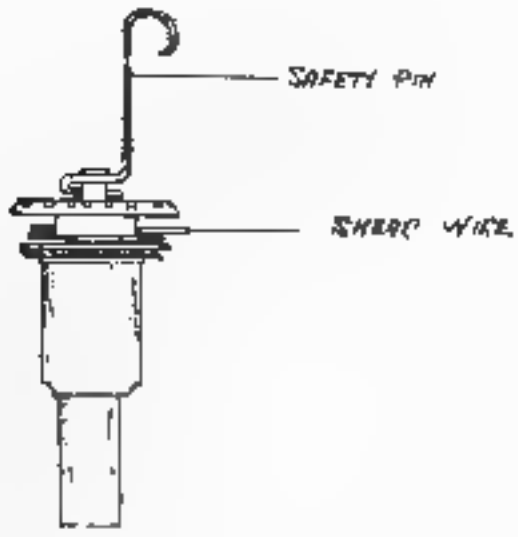


FUSE.

DUTCH MINE A/TK.

DUTCH MINE, ANTI-TANK.

This is a small, cylindrical mine, more dome-shaped than the British mine. The mine lid is not normally removed from the body, but is held in position by four screws, a light spring keeping it raised off the body.

In the body of the mine is a screwed hole to receive the fuse. A corresponding hole on the lid is closed by a screwed plug.

The fuse assembly screws into the body of the mine. For inspection, insure that none of the mine is badly dented, or has the mine cover, knurled plug or the retaining screws missing.

Arming and testing.

(a) Unscrew the knurled plug on top of the mine cover, thus exposing the waxed cork.

(b) Check for the presence of the coil spring under the mine cover by depressing the cover by hand.

(c) Extract the cork pressing down on the mine cover to expose it fully. Care must be taken to prevent any pieces of the broken cork to fall into the detonator cavity, which would prevent the arming of the mine.

(d) Insert a fuse assembly fully into the fuse cavity with the safety-pin in place. Depressing the mine cover, screw the fuse as far as it will go, without force.

The knurled flange should lie closely on top of the mine body itself. If this is not possible, unscrew the fuse and inspect the fuse cavity for obstruction, TNT or broken cork. If the cavity is free, and if another fuse cannot be screwed home, reject mine.

(e) With the fuse in position, the knurled plug in the mine cover cannot be reinserted until the safety-pin is withdrawn, on account of the vertical arm of the latter. Therefore, unless the mines are to be armed or laid at once, remove the fuse, repack and replace the knurled plug.

Arming and laying.

(a) Remove the knurled plug.

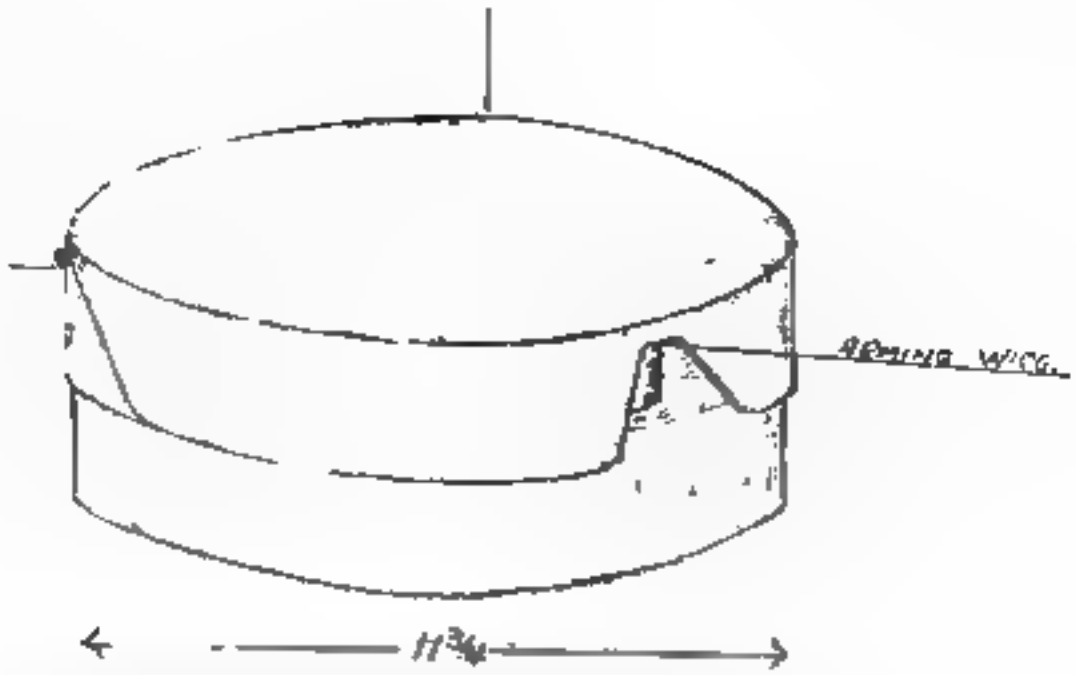
(b) Examine the fuse, making sure that the copper shear-wire (located under the knurled flange) is in good condition. If so, remove the split-pin and place it with its attached cord in the hole, for further use if the mine is lifted.

(c) Insert and fully screw in the fuse, depressing the mine cover while doing so to enable the fingers to grip the knurled flange.

Arming and laying.

(d) When fully satisfied that the fuse is screwed home, release the mine cover. Then refit the knurled plug. During this operation, do not press heavily on the mine cover. No force is necessary during any of the above operations.

(e) Lay the mine on top of the safety pin (already in hole), observing the normal precautions to prevent bridging.



ALUMINIUM A/TK. MINE.
D.Z. 35, T.Mi.Z. 42

ALUMINUM ANTI-TANK MINE.

This mine, which was made from salvaged material by the Germans in Tunisia, has not been found outside that area. It consists of a cylindrical aluminum container with a false lid and cover.

The loose lid has three holes through which the igniters protrude. These are caused to function by pressure on the cover. Three igniters per mine are used and they may be either of the D.Z. 35 type or the other type used in the Tellermine T.Mi. 42 (T.Mi. Z. 42).

To prepare the mine.

(a) Using the D.Z. 35 igniters, screw into the sockets of the prepared charges (which are placed below the three holes in the false lid).

(b) Replace the cover so that the cut-away portions are opposite the safety-pins of the igniters, and lay out the cords attached to the safety-pins.

Using the T. Mi. Z. 42 igniters. Same as above (but without safety-pins).

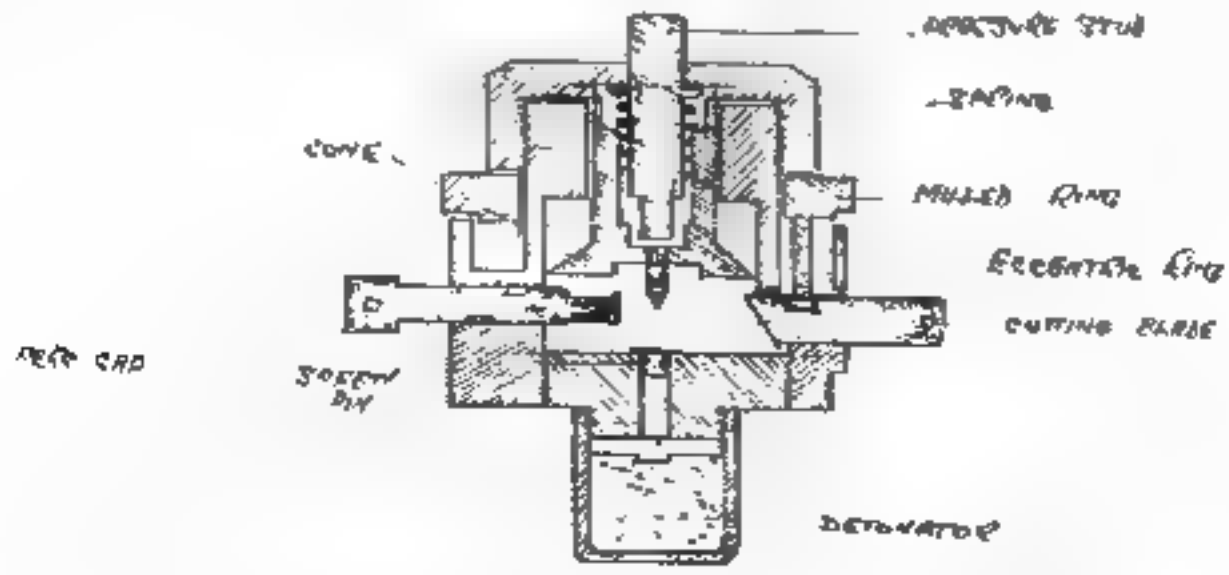
To arm the mine.

(a) Using the D.Z. 35 igniters, pull the cords attached to the safety pins and withdraw all three.

(b) Using the T.Mi.Z. 42 igniters, the mine, when prepared above is armed.

To lift mine.

There are no provisions made for the use of additional igniters with this mine and no obvious ways of fitting booby-traps. When found, these should be marked conspicuously and the sappers informed, as there are no easy ways to attach a cord or cable for destruction.



ITALIAN. C.V.P. A/TK or A/P.
(Circular Variable Pressure)

NEXT PAGE

ITALIAN CVP A/TK A/P (Circular Variable Pressure.

Total weight of mine 7 lbs.

Explosive filling 3 1/2 lbs. Tolite or TNT.

Preparation of mine.

(a) Remove pressure plate.

(b) Screw igniter into mine, having insured that the detonator is screwed tightly to bottom of igniter.

Arming as A/P with trip-wire.

(a) Remove trip set-screw, and turned milled ring until red mark is set at K=80 lbs.

(b) Lay out safety pin withdrawal cord.

(c) Replace lid and secure with pins.

(d) Withdraw safety-pin cord.

Disarming, normal.

Attach 50 yards of cable to leg of mine and pull clear, from under cover.

Disarming, silent.

(a) Remove pressure plate and leave upturned beside mine.

(b) Insert nail or wire in safety-pin hole of igniter.

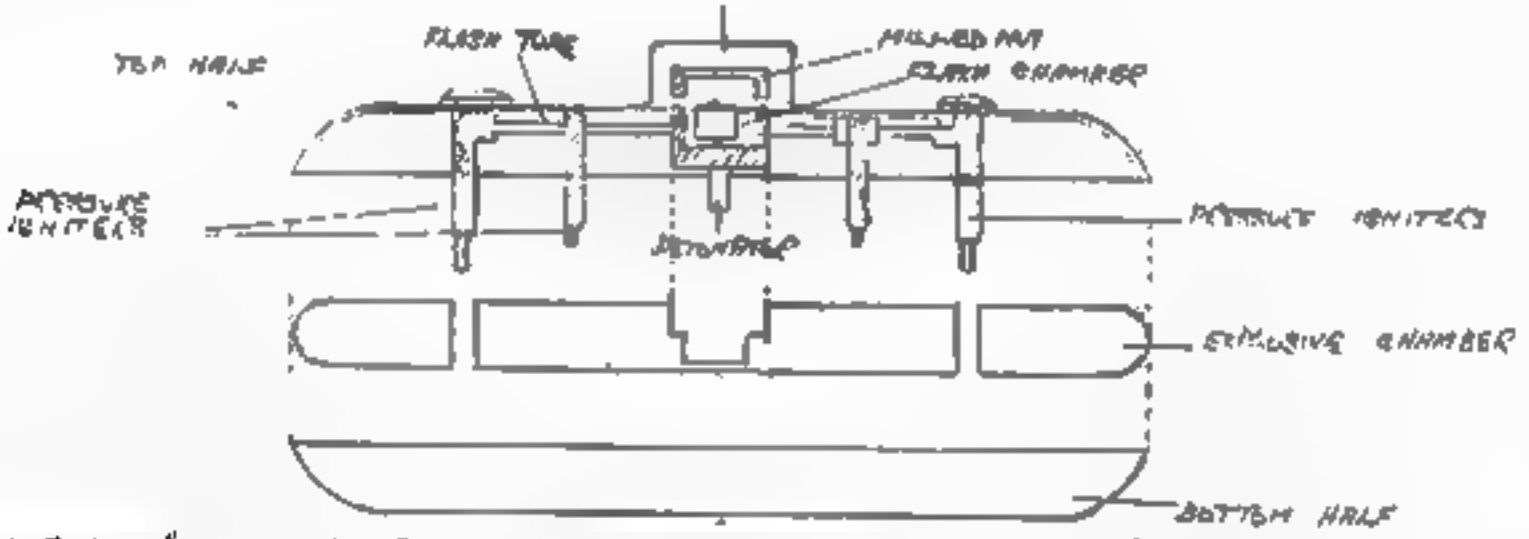
(c) Cut trip-wire if present.

Pressures.

K. 80 lbs. A/P 1 = 220 lbs. A/TK

2. 440 lbs. A/TK 3 = 660 lbs. A/TK

N. 770 lbs. A/TK H = Trip-wire A/TK



GERMAN L.P.Z. PARATROOP A/P or A/TK.

GERMAN LPZ PARATROOP A/P or A/TK

This mine is designed for use by paratroops. It can be activated by a vehicle as well as a tank. The body of the mine must be crushed in order to fire the five detonators, which are connected to a central chamber, which contains the main detonator. The detonator can be blanked off from the igniter by means of the milled knob above the central chamber. If the nut below any igniter is removed, the latter becomes very sensitive and the mine will operate as an anti-personnel mine.

To arm the mine.

(a) Remove central dust cap.

(b) Turn milled knob as far as it will go in the opposite direction to the arrow on the knob.

(c) Replace the cap.

Disarming, normal.

Attach 50 yards of cable or cord and pull clear, from under cover.

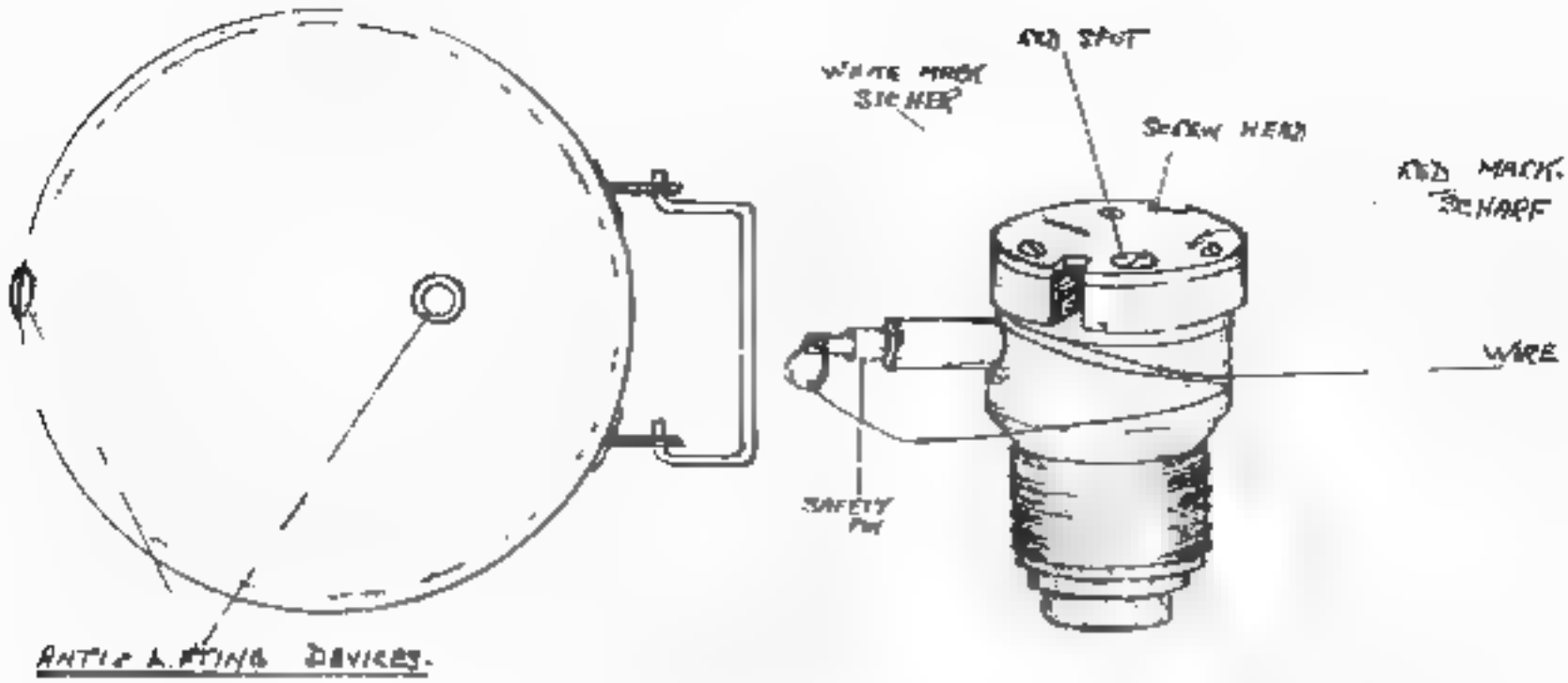
Disarming, silent.

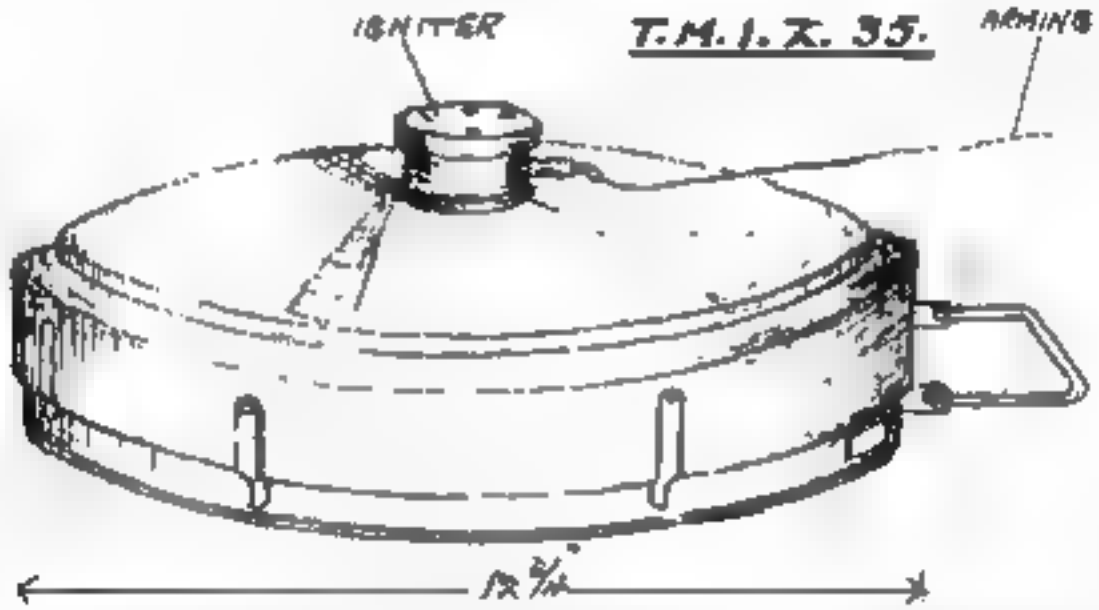
If dust cap is missing, carefully clean dirt from milled knob. If dust cap is in position, mark it and send for sappers. Very carefully turn mine on its edge and turn milled knob to its full capacity.

This mine can be laid as anti-personnel by the removal of the five igniter's nuts situated on the base of the mine. Nuts are left on for anti-tank, necessitating the crushing of the lid.

Weight of mine 9 lbs.

Filling 3 1/2 lbs. Tolite or TNT.





GERMAN TELLERMINE (1935 model) T.M.I.Z. 35. No. 1.

GERMAN TELLERMINE (1935 model) TMIZ .35 No. 1

This is the standard German anti-tank mine. It measures about 13" across and is fired by a pressure of 300 lbs. There are two holes (one in the base and one in the side) for additional igniters, which act as anti-lifting devices or booby-traps. The mine may also be booby-traped by a cord attached to the handle. This cord is tied to an igniter screwed into a prepared charge or into another mine below the first one.

To prepare the mine.

This mine is usually carried with a detonator and igniter in place.

To arm the mine.

(a) Untie the wire attached to the safety-pin (if wire or cord is present) and lay it out full length.

(b) Turn the screw head on top of the igniter TMIZ .35 until the red spot moves from opposite the white mark SICHER to opposite the red mark SCHARF. For this operation, use a coin and NOT a screwdriver.

(c) If the cord is present and has been laid out, cover the mine and camouflage it.

(d) Withdraw the safety-pin by pulling the laid out cord.

NOTE.- If the cord has not been attached to the safety-pin, the latter must be withdrawn before covering the mine. In that case, extra care must be taken in not exerting too great a pressure on the mine while covering and camouflaging it.

To lift the mine.

(a) Lay out 50 yards of cable or cord and attach it to the mine, pulling clear from under suitable cover.

(b) Attach the nearest end to the mine by means of a loop over the igniter and secure it without moving the mine or the igniter.

(c) Pull the mine clear. If it has been booby-trapped, it may explode during the operation.

To neutralize the mine.

(a) If there are additional igniters in the mine, which have not worked, identify them and neutralize according to the instructions on arming.

Igniter, to arm.

Tie a black cord to the hole in the igniter ZZ .35, and secure the free end to some object firmly fixed in the ground. Then withdraw the safety-pin.

To disarm.

Insert a stout wire or nail through the safety-pin hole, and secure by bending. Trace the trip-cord to the far end and if present, disarm the igniter. Cut the trip-cord.

In battle experience, the following procedure will be adopted in neutralizing the igniter.

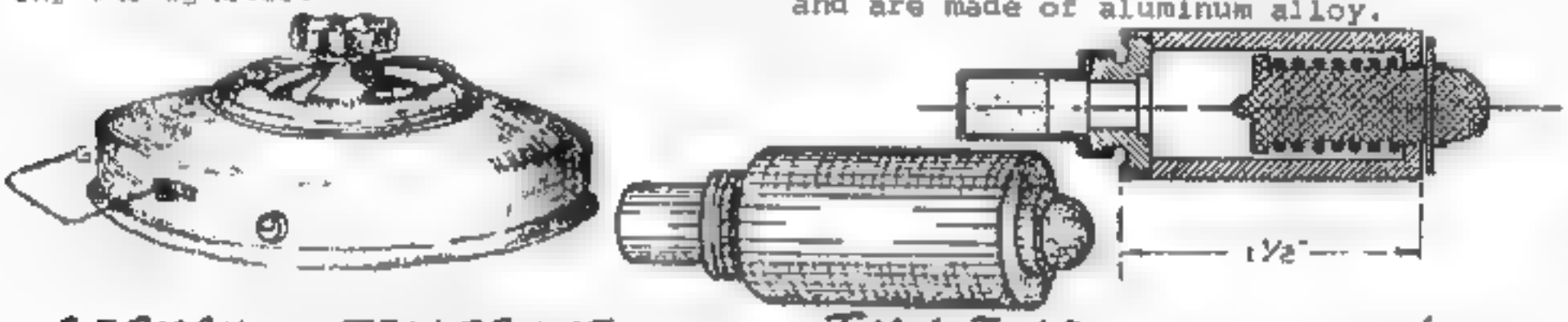
(b) Using the coin, but not a screw driver, turn the screw head on the igniter so that the red spot moves from opposite the red mark SCHARF to opposite the white mark SICHER.

(c) Push home the safety bolt.

(d) If neither of these operations can be performed easily, remove the igniter from the mine, and, pointing the cap away from the body (b), repeat and (c), above.

(e) Replace the igniter. If the igniter cannot be made safe as instructed at (d, leave it out of the mine and mark both conspicuously.

To form barriers across roads, etc., Tellermines may be joined by pressure bars. These are 4 ft., 6 inches long and are made of aluminum alloy.



GERMAN TELLERMINE. T.M.I.Z. 42. No. 2.

GERMAN TELLERMINE TMIZ .42, No. 2.

This mine is similar in size to the ordinary Tellermine. It can be distinguished by the presence of the small, fluted pressure plate (about 6 inches in diameter) and by the fluted, screwed cap at the center. Like the Tellermine (1935 pattern) it has two holes for additional igniters and may be booby-trapped in the same way.

To prepare the mine.

(a) Unscrew the fluted, screwed cap at the center of the mine.

(b) Attach a detonator to the base of the igniter by means of the screwed, threaded collar.

(c) Insert the igniter with the detonator attached.

(d) Replace the screwed cap.

To arm the mine.

When the mine is prepared, as above, it is armed. NOTE, there are no safety devices in this mine.

To lift the mine.

(a) Lay out 50 yards of cord or cable from the mine to suitable cover.

(b) Attach the end nearest the mine to the fluted, screwed cap and secure without moving the mine.

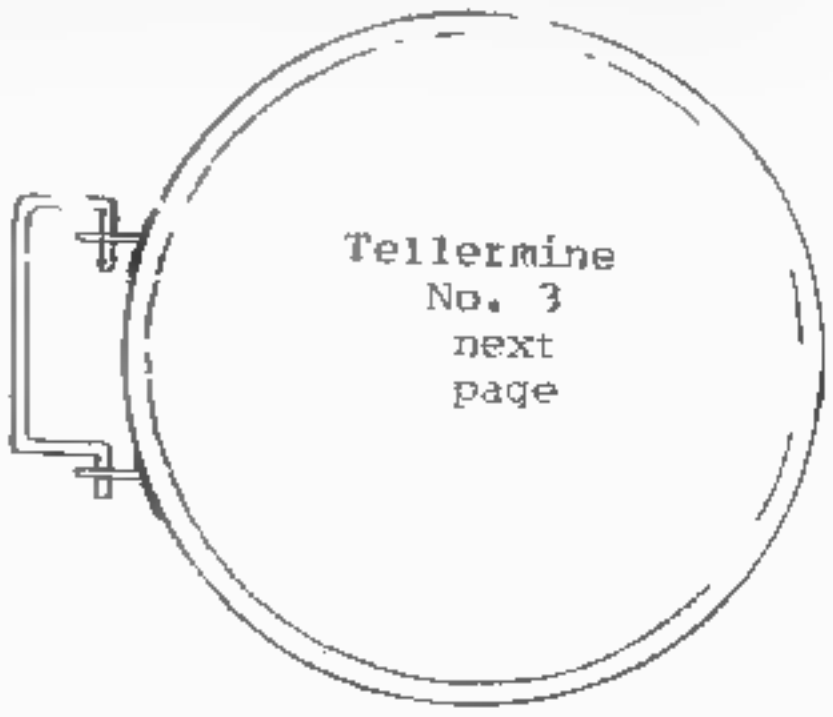
(c) Pull the mine clear. If it has been booby-trapped, it may explode during this operation.

To neutralize the mine.

(a) If additional igniters in the mine have not worked, identify them and neutralize according to instructions as in the Tellermine No. 1.

(b) Unscrew the fluted dust cap.

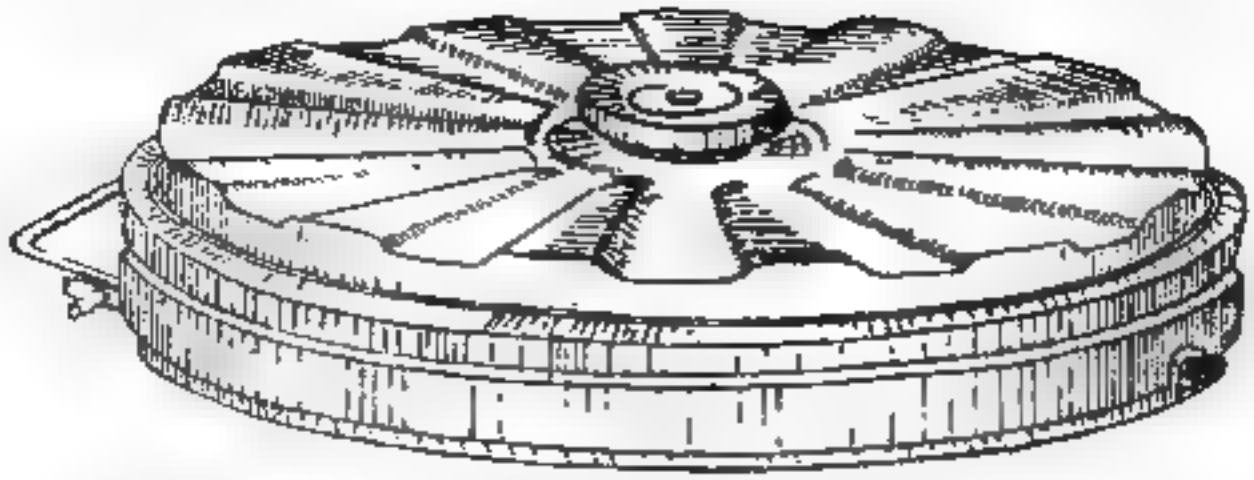
(c) Remove the igniter and detonator



complete.

(d) Replace the screwed cap.

(e) Leave the igniter beside the mine and mark it conspicuously. The detonator, if trodden upon, is very dangerous to personnel.



TELLERMINE No.3.

GERMAN TELLERMINE TMIZ .35 STEEL No. 3.

This mine is similar in dimensions to the TMIZ .35 No. 1. It can be easily distinguished by the fluted pressure plate which covers to whole of the top of the mine. The main igniter used in this mine may be either of the types used in Tellermine TMIZ .35 (1) or TMIZ .42 (2). The mine may have anti-lifting devices or may be booby-trapped as already described in 1 and 2.

To neutralize the mine.

Identify the igniter and proceed as in No. 1 or No. 2 as described.

To prepare the mine.

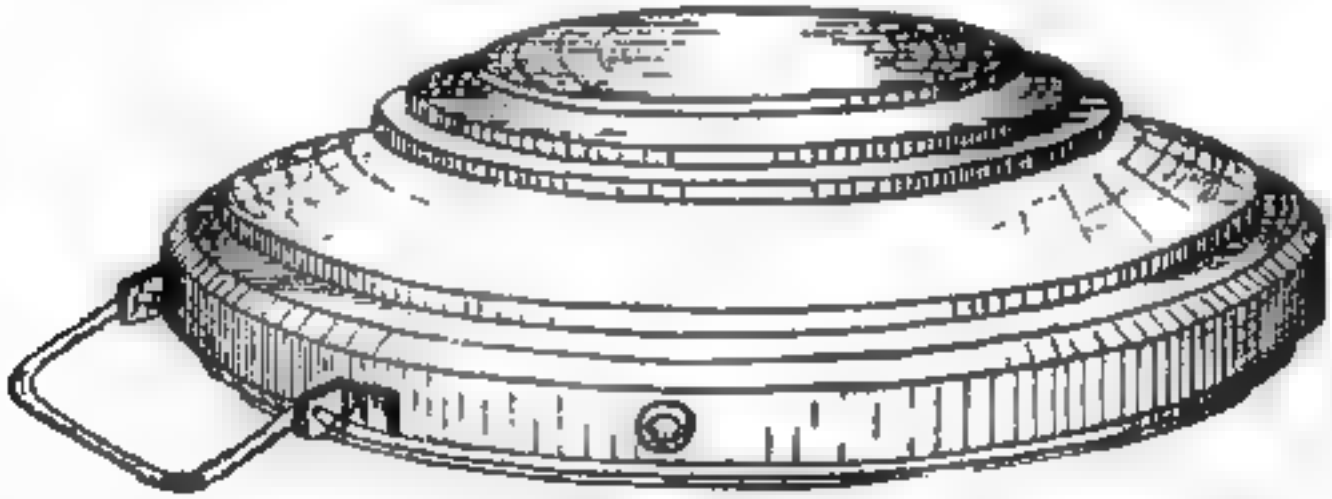
Proceed as in No. 1 or No. 2, according to the igniter used.

To arm the mine.

Identify the igniter and proceed as in No. 1 and No. 2, as described.

To lift the mine.

Proceed as in No. 1 or No. 2 as described.



TELLERMINE No. 4.

GERMAN TELLERMINE TMIZ .43 No. 4 (Mushroom)

This mine has very roughly the same dimensions as the original (1935 pattern). It is, however, distinguished from the three models previously described in having a "mushroom head" which screws into the main igniter socket. There are two threaded holes for the insertion of additional igniters as in the other Tellermines.

To prepare the mine.

(a) Unscrew the mushroom head and remove it.

(b) Insert the igniter TMIZ .42 complete with detonator.

(c) Replace the mushroom head.

To arm the mine.

When the mine is prepared as above, it is armed. There are no safety devices in this igniter.

To lift the mine.

(a) Lay out 50 yards of cable from the mine to suitable cover.

(b) Loop the end nearest the mine around the mushroom head and secure it.

(c) Pull the igniter and mine clear. If it has been booby-trapped the mine may explode during this operation.

To neutralize the mine.

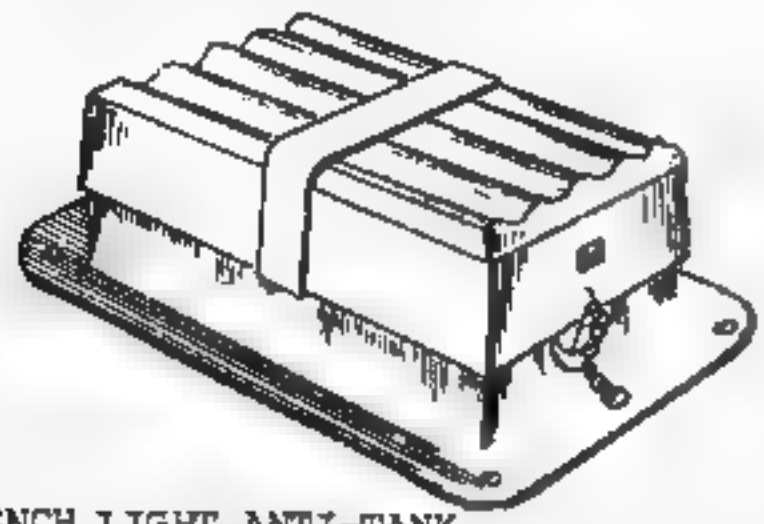
(a) If additional igniters have not functioned in the mine, identify them and neutralize according to the instructions in No. 1.

(b) Unscrew the mushroom head.

(c) Remove the igniter and detonator complete.

Next page

(d) Replace the mushroom head.
(e) Leave the detonator beside the mine and mark it conspicuously. The detonator, if trodden upon, is dangerous to personnel.



FRENCH LIGHT ANTI-TANK.

This box-shaped mine has a corrugated lid below which are two igniters. During transit a channel-shaped safety bar, inserted through the end of the mine and running the full length of it, protects the igniters.

To prepare the mine.

These mines are usually transported with the igniters in place.

To arm the mine.

Take out the pin from one end of the safety bar and pull out the bar by the ring at the other end.

To lift the mine.

(a) Lay out a 50 yard length of cord or cable from the mine to a suitable cover.
(b) Attach one end of the cord or cable to the chain at the end of the mine.
(c) Pull the mine clear, from under cover. If the mine is booby-trapped, it may explode during this operation.

To neutralize the mine.

(a) Detach the chain holding the lid and carefully lift off the latter.
(b) Unscrew the ywo igniters by hand, taking care not to press on the heads of the igniters.
(c) Leave the mine uncovered on its edge and place the two igniters in the upturned lid.

N.B. Since the detonators remain attached to the igniters, they must be handled with care.

This mine is very often considered booby-trapped and used by the enemy.

OPERATIONAL MINEFIELDS.

After the capture of enemy positions or objectives, the reorganization of that objective must nearly always include the laying of a minefield to protect positions against a possible counter-attack,

(b) Such minefields must be laid quickly by forward troops.

(c) The field must be rough and ready, but efficient and easy to lay, and must suffice until such times as a proper stock mine field can be laid.

(d) The Hawkins No. 45 A/T mine has been found the ideal mine for this purpose of laying an operational minefield.

Drill for laying.

(a) Minefields are laid in blocks 150 yards long.
(b) Each block is laid by a party of 32 men.
(c) Unloading points are fixed as near to the site as possible, but if shelling etc., is heavy, must be a mile in the rear.
(d) Mines are brought to unloading point by vehicle and each 3 ton lorry carrying sufficient mines and equipment to lay 3 blocks or 450 yards.
(e) At unloading points, vehicles are unloaded and igniter sets made up (miner's flash and detonators), from then on, they must be transported by hand.
(f) Each block is laid at a density of one mine per yard of front, and therefore contains 150 mines. Also used in each block are 16 screw pickets and 9 rolls of dannet wire.(?)
(g) Three ton lorries can carry sufficient mines for three blocks, therefore has a load of 450 mines, 48 pickets and 24 rolls of dannet wire. (?)
(h) Each party of 32 men are used as follows:- 30 men are used to lay the mines and they carry five mines each and 10 igniter sets for arming. The remaining two men carry the 16 pickets, 8 each.
(i) The party carries the mines to the starting point and lines up in a single line, spaced 5 yards intervals and all facing in the direction of the enemy.
(j) The 30 men with five mines apiece each advance by a given order and a given number of paces, halt, lay a mine. The laying of the other mines is as follows:-

Forward 5 paces, 1 pace left, lay.
Forward 7 paces, 2 paces left, lay.
Forward 6 paces, 3 paces left, lay.
Forward 5 paces, 4 paces left, lay.

By this method, one complete row of mines is laid at a time and ends up with a density of one. Spacing between the rows is optional. The order or pattern of laying can be altered, according to the rotation or order given.

(k) When the last row has been laid, pickets are put in clear of the last row at 10 yard intervals.

(1) 18 of the mine layers return and collect the 9 rolls of wire, one roll to two men, and drop over the pickets. If triple damment wire is required, this will be carried out 3 times.

Carrying of mines.

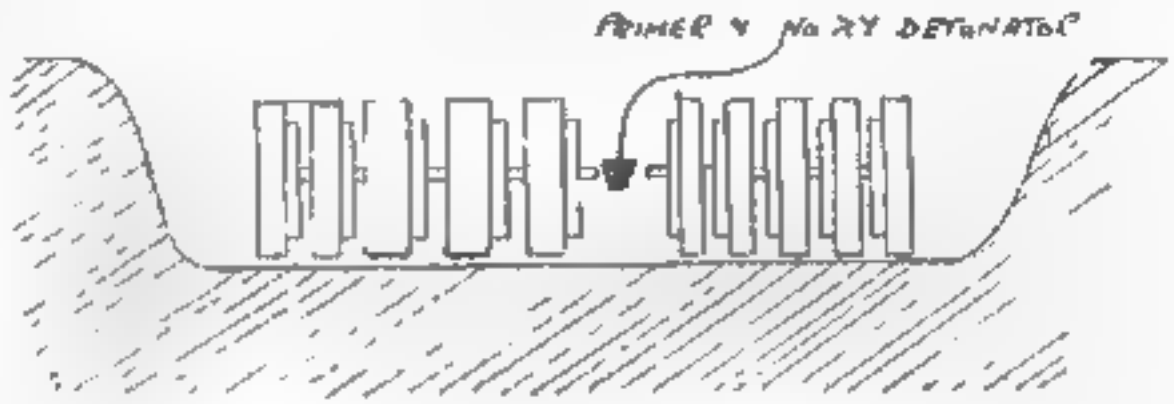
(a) Mines can be carried armed or otherwise. If armed, this reduces the time spent in actual laying and is normally done when time is essential. At the same time, if armed, it increases the danger from accident, if any should be accidentally dropped. If armed, mines should be carried in haversacks.

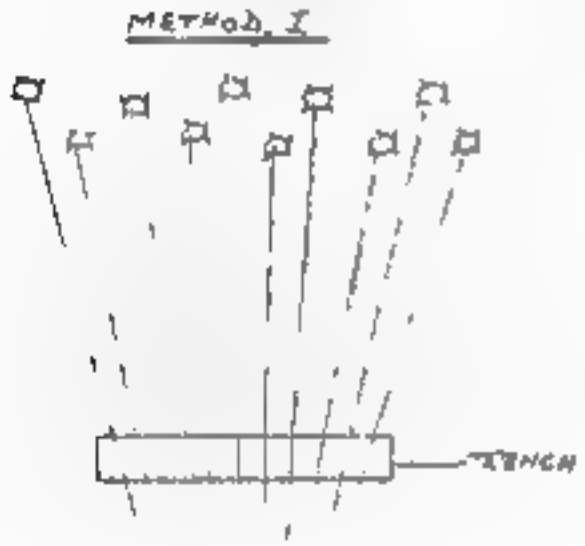
(b) It is usually best to carry mines unarmed unless circumstances arise where delay must be avoided.

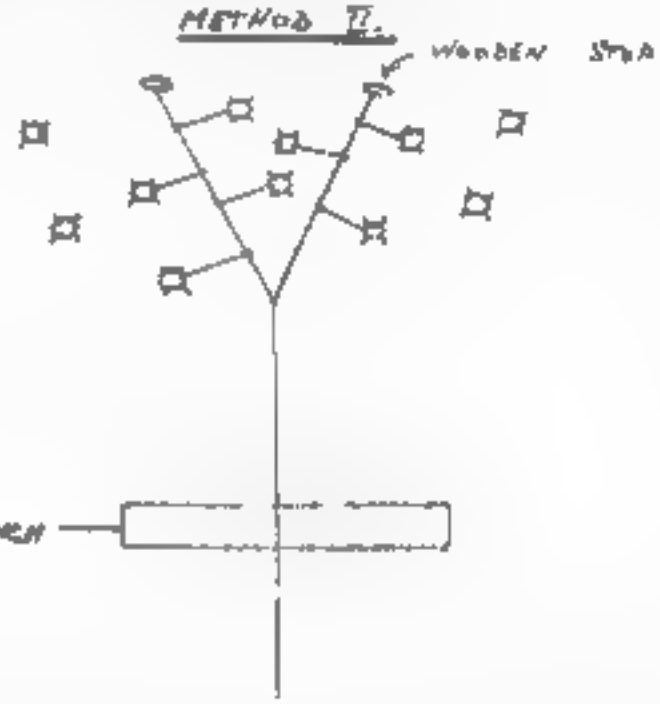
(c) Fields must always be picked up by the men (same) as laid it if possible or where possible and mines must be disarmed immediately. No mines must be packed or loaded on vehicles armed. If unable to disarm, DESTROY!

The lifting is just the reverse to the laying. Mines must be laid longways on towards the enemy, to avoid a possibility of them being picked up between the sections of tanks' tracks.

Each brigade carries 4000 complete mines.







DELIBERATE CLEARANCE OF MINED AREAS.

After an advance it may be necessary to clear own and enemy minefields which impede movement in near areas. All clearance should be done by remote control.

The method employed is as follows. After locating the mine by eye, prodding or detector:-

(a) Carefully uncover the mine.

(b) Carefully attach 100 yards of cable to the mine.

(c) Retire to the full length of the cable.

(d) Draw the mine over the ground towards a shallow V shaped trench already dug to receive it.

The mines should be drawn ibto the trench until they are 10 in number, when they can be conveniently destroyed by one guncotton primer.

The mines should be placed on edge with their covers facing inwards as shown.

ROAD CLEARANCE, MINES INDICATIONS AND WARNINGS.

The following are hints for locating or expecting mines laid by the enemy in a delaying action.

(a) Disturbed ground. This will be readily seen if mines have been laid recently, but rain will quickly obliterate visual sign.

(b) Empty mine boxes and packings.

(c) Pickets or stakes, if planted in the ground for no apparent reason, especially where tracks turn off from main

roads.

(d) Barbed wire or traces of the removal of these fences indicate possible mine fields.

(e) Jerrycans or other objects, placed on the milestones or kilo-stones, signs for rear guards.

(f) Unusual objects or marks, also near guard signs.

(g) Vehicle tracks. Do not assume that vehicle tracks are safe, especially on aerodromes, etc.

Mined areas.

Experience has shown that the following areas are the most likely places for mining and around roads.

(a) Potholes, or bites in the tarmac and repair patches.

(b) Crossroads, junctions or where the road narrows.

(c) Roadsides around craters or any other roadblock where diversion is necessary.

(d) Parking places, courtyards, etc.

(e) Telegraph poles with the wires taut.

(f) Around kilo-stones, notices, old vehicles, etc., and any objects of curiosity. Most such objects are booby-trapped.

(g) In culverts, under the tarmac, where banks run down from the road as at bridges, etc.

The following warnings indicate mines.

(1)"Mines, Keep out" or "Danger, Mines".
(2)Red triangles on fencing.
(3)Red and white gap markers.
(4)White tape.
(5)Amber and green gap lights.
(6)White triangles of tin, with word "Mines" painted on.
(7)Safe lane signs.
(8)"B.T." signs, meaning booby-traps.
(9)Skull and crossbones.
(10)Mines placed on kilo-stones or on the side of the road, in conspicuous positions indicates that mines have been lifted from the tarmac but not from the sides of the road.

Operation procedure.

The actual clearing up is done in two stages.

Stage 1. Clearing a one-way route for men and vehicles, usually the main road or most direct rout. This is done by removing all mines and traps from the road surface and by-passing craters and any immovable object. This stage is usually done by leading units.

Stage 2. Checking the tarmac, improving by-passes and filling in craters. Making and marking safe lanes, leading off road to dispersal areas, clearing 20 feet, which should include telephone poles, fencing and marking all mine fields alongside of road, where mines have not been lifted.

Method of clearing tarmac.

A line of mines, that is one man per yard of road with bayonets or prodders, and two each side to cover the first two yards of the shoulders. These men line up and walk the road and shoulders, prodding for mines as with gapping drill Each man should have some lengths of 12 gauge wire, cut up for safety-pins.

The first vehicle should be not less than 30 yards behind. This vehicle must contain equipment which must include lengths of rope and cable with grapnels.

Mines. The men on the road surface must prod potholes and soft spots for mines. If doubtful, check with detector.

All mines located must be dealt with by the man who finds it and lifted and disarmed as laid down (pull with cable).

When mines have been made safe, they should be stood up in a conspicuous position on the side of the road to warn following troops (such mines must have the anti-lifting sockets visible).

Craters. If craters are met, leave them alone and make a diversion from a point not less than 200 yards before and beyond it so that it skirts the crater by at least 150 yards. Don't use an obvious turn-off. By going 150 yards around you invariably miss most mines, laid each side of the crater (areas around craters are nearly always heavily mined). Tape must be laid, and prodding with bayonet drill carried out in the normal way to make the lane safe.

Wire fence obstacles, or all movable road-blocks.

Approach carefully and watch for shrapnel mines with trip-wires, especially where barbed-wire obstacles are met. Always clear mines from the sides or around obstacles before attempting to remove it, to avoid them being buried deeper. Should obstacles be attached to crater and charge in the road, this would make mines difficult to find. When this is done, pull road block from a safe distance with cable. If crater charge is fitted, soil will fall on ground already cleared. Do not walk around the end of the obstacle, or through obvious gaps in the wire before clearing mines.

Check the places where obstacles have been standing, for mines. Pull vehicles, do not move brakes, wheels, steering

wheel or gear lever, etc., booby-trapped. Make sure that when moving vehicle off the road you do not push it on to other mines on the side of the road.

Suspect all empty cases, crates or objects on the side of the road. Pull all mines with cable, also any suspicious objects. Keep at least 50 yards back when pulling and lie down.

Suspect all buildings of being booby-trapped. Report stretches of mined roads or craters. If mine is booby-trapped and explodes, fill in the hole. If not booby-trapped, prod for further mines underneath, such as double Tellermines. Do not allow others to run to a man's aid if he is killed or wounded by a shrapnel mine. There will be others. Always check approach.

METHODS OF MINE LAYING AND LIFTING.

Mines are essentially a defensive weapon and are laid according to the circumstances and country available. The methods of laying mines are laid down as a drill to give the maximum protection to those engaged in the operation to be carried out as speedily and efficiently as possible. Of course, there is a procedure adopted always when it is necessary to lay mines as quickly as possible to obstruct advancing forces etc., and this is known as "indiscriminate laying".

When the minefield has been laid in a certain position, the entire operation has to be planned on paper, and this minefield is called a "Stock Minefield", which is well-marked by warning signs and barbed-wire fences. This operation will be described later on.

The drill for laying an individual mine is equally as important as that used in laying a complete field. It will be found that the following points are essential:-

(1) Mines should always be carefully examined individually before being packed.

(2) The cases should be examined after packing and carefully stacked.

(3) Mines must never be carried in an armed condition, as several fatal accidents have occurred through mishandling armed mines.

(4) Shovels are used to dig the hole for the mines but never used during a lifting operation.

(5) The hole varies in depth, but the mine should normally be covered to a depth of 1" to 2", so as to afford good camouflage.

(6) Mines are sometimes laid to a depth of 2' to 2' 6", but this is only done at the order of a Higher Command, and the depth of the mine recorded on the pro-forma.

The object is two-fold:-

(a) To defeat the detector.

(b) So that numerous vehicles, by continuous movement, will depress the earth on top of the mine sufficiently to acuate the mine. Nothing is more demoralizing to men than to suddenly find that the vehicle either in front or behind has run over a mine after the road or track has been used for some time. It leaves them wondering if they will be the next to suffer the same fate, and with their nerves frayed, other accidents may occur.

(In case you didn't understand this, it is fiendish and beautiful! The idea is to bury the mine deep enough that a tank or truck will not explode it. But, as more vehicles go over it, the ground will be compacted by degrees so, when the personnel are confident that the road is clear of mines, the next vehicle compresses the earth just that little more to blow the mine. Is that beautiful or not? Ed.).

(7) When laying a mine, the prone position is adopted irrespective of the state of the ground. This does not necessarily mean safety for the individual, but it serves as a warning to passers by. Should a person be seen in the prone position, it is obvious he is dealing with something dangerous and no one should be within 40 yards of him.

It is perfectly obvious that the person laying the mine would not be safe should the mine be set off by accident. But if he were stooping over the mine, his action could be mistaken and draw the attention of a passer-by.

(8) Mines should not be nearer than 5 yards to each other. This to prevent Sympathetic Actuation, which, by the way is entirely different from Sympathetic Detonation.

Sympathetic Actuation occurs when two mines are spaced too closely together and the blast from one mine operates the fuse of the second. The second mine is thus actuated in the same way as if a vehicle had passed over it.

Of course, this does not occur in each instance. But you can imagine the possible effect if a row of mines was laid with a four yard spacing between each. Some British mines were made to withstand the blast effect of a nearby mine. In one case, now obsolete, a sorbo rubber ring (giving a cushion effect)

was used. Of course, the surface area of the lid, which pivots on the fuse, has a large bearing on the subject. For the blast can only affect the fuse if the lid offers sufficient surface area. But this was remedied by the introduction of a spider, more of which will be explained further on.

Sympathetic Detonation occurs only between explosives and is caused by the passage of the detonating wave, which is only effective within a certain radius. Thus, an air space can break the continuity of a detonating wave, the radius of which depends on (1) its speed and (2) the amount of explosive.

When an explosion occurs, the blast is felt for some distance around the explosion. But the farther one is away from the spot, the weaker the blast. When the detonating wave originates, its speed is a thousandth of a meter per second.

For instance, a mine filled with TNT radiates detonating waves at a speed of 7500 meters per second. This represents almost 4 3/4 miles per second. But the further the waves travel, the weaker they become, until they are ineffective in their ability to initiate other explosives, but still retain sufficient blast power to smash that explosive. Therefore, Sympathetic Actuation is a mechanical action involving two armed mines, wheras Sympathetic Detonation occurs between explosives and can be rendered harmless by an air space.

(9) When moving through a minefield, it is best to take long strides on tip-toe, treading as lightly as possible. Panic in a mined area must be avoided at all costs. The slightest movement increases the weight of the individual ans a running man almost doubles his own weight. Consequently, it is possible for a man to actuate an anti-tank mine by accident, which is normally safe under his own weight, if he loses his head and runs blindly. The fact can easily be proven that a man's weight is considerably "increased" in this respect:-

(a) Casting one's mind back to days when it was possible to record one's weight on the weighing machine in Woolworth's, the weight was actually recorded when the needle was stationary. But the movement of the individual in stepping off the machine caused the pointer to move forward, shoving an increased weight.

(b) If a person treads on a chap's toe, it is not as bad as if he is running clumsily by and lands on that unfortunate individual's foot. Also, if a man is running blindly, he cannot possibly avoid trip-wires, etc., which are definitely anti-personnel in nature.

(10) When lifting mines, each man should be in possesion of at least 24 safety pins: These can be wire or nails, being of 12 guage in thickness or more and not less than 1 1/8" in length.

(11) Never cut a trip-wire without first acertaining whether it is tight or slack. Safety-pins should always be inserted. Always remember to trace trip-wires to both ends. A taut trip-wire is naturally holding something, and if cut, it will release it. The moral is "never cut a taut trip-wire and never pull a slack one".

(12) Always check fuses for tightness in fitting to mines and never force a tight fuse into a mine.

(13) Check all mines with removable covers, to insure they fit correctly.

(14) Don't bunch together; one man, one mine, one chance the first and last.

(15) Here are nine examples of famous last words:-

(1) Come and watch me lift this one.
(2) Let's cut the wire.
(3) Throw me a tin of fuses.
(4) These mines don't seem to be booby-trapped.
(5) These mines don't seem to go off when you walk on them.
(6) That looks a good billet, electric light and all.
(7) Nice bit of loot, this.
(8) This lid and fuse are jammed, throw me a hammer.
(9) I always smoke on the job.

The enemy, having captured a large number of British mines in the early years of the war, have made good use of them in recent months. In one sector, it was found that a large percentage of captured mines were used along with German mines. Thus, British mines laid by the Germans must be treated as enemy mines. No provision for booby-traps has been made on British mines. But the enemy has made that provision, and, because "familiarity breeds contempt", Allied troops have overlooked the possibilities of booby traps, and have not exercised sufficient care in lifting, resulting in casualties.

Casualties have also occured through carelessness, caused by individuals rushing to view damaged vehicles or to render aid to injured comrades. This must be prevented at all costs, and persons concerned ordered to proceed in an

orderly manner, systematically clearing a way to their objective.

Methods of mine detection and lifting.

Bayonets.

This is the slowest, by far, but certainly the surest method of detecting all mines, except Plastic Mines. When prodding with a bayonet it should be held at an angle of 45 degrees with the bevelled edge underneath, so that the bayonet will glance off a mine. There is one correct way to hold a bayonet and that is to grip the handle tightly, for a slack grip will cause friction between the handle and the palm of the hand, resulting in a blister in one of the worst places possible.

The correct drill is to prod every 3" in a line to the left and right, and linking up with the man on either side. The prodders should then move forward 3" each time. Average speed forward over a yard frontage is 1 1/2 yards per minute.

Detector.

There are several types of detectors, each based on the original, produced in October, 1941. They each have different standards of accuracy. But the biggest drawback is the inability to detect any mine other than one with a metallic container.

Americans, however, have invented a "Homogenous" detector, capable of locating any object in the ground which is not consistant with the true nature of the ground. Therefore, rocks, metal rods planks of wood, bottles and even air cavities are located and consequently so much time is wasted.

Mine destroying tanks.

These have developed rapidly in the past 12 months, but are not 100% perfect as deeply laid mines are often dormant for some considerable time, unless the earth is packed down hard enough to set them off.

Dogs.

It has recently been revealed that dogs have been trained to locate mines, adding one more laurel to their already large bouquet. These animals move forward with the Sappers, etc. When they locate a mine, some sit stock still, others whine, whilst some emit a low growe. But they do not touch the ground covering the mine, which is then marked

When the mines are located, various methods of removal are employed. The most common is the use of a 50 yard length of cable, which is attached to the mine, and the mine removed by the "Lifter" from under cover.

It is necessary to allow 30 seconds delay before approaching the mine after removing it, in case a delay action fuse is fitted and is set into operation, when the mine is moved.

During these lectures, you will see how easy it is to make mistakes by curiosity, ignorance, over-eagerness and anxiety to complete the job. You will realize how great the debt is, that the Army owes the R.E.s (?), for their work arlier in the war. Too late, it has been realized that the Army needs training in mines and booby-trap warfare. Not to do the R.E.'s job but to safeguard themselves from injury in ignorance of the mines with which they may be confronted.

This course is similar to arms drill. You were taught to fire a rifle when you first joined up. Not to engage the enemy as front-line troops, but to protect yourselves should you suddenly find yourselves without any other support. So it is with mine warfare. This training is designed to give you sufficient knowledge to avoid danger from mines and not to make you "Mine Lifting Personnel".

Methods of mine destruction.

This is rather a bigger subject than first thought. For the majority of persons are totally ignorant of the various methods by which mines can be destroyed. Asked how they would destroy a mine, or mines, the majority suggest small arms fire, others say to pour some petrol on it and set fire to it. A small minority who sense the danger in the previous suggestions admit they don't know.

Well, the suggestion of small arms fire is a foolish one and here's why. First, a rifle bullet will not detonate bulk explosives. But even if a marksman can see the mine, there is a very slim chance of him striking the fuse or igniter and operating it so the mine is destroyed. Ofttimes the mine is riddled with bullets without setting it off, but unfortunately the fuse is damaged and the mine is ultimately pronounced a dud by the cocksure marksman. Then it goes off as soon as some unfortunate person moves it.

The small arms fire suggestion can only be effective if (1) the mine is in full view, and the fuse also, so the marksman who must be (2) a skilled shot. To think of trying to set off a mine which is below ground level, is ridiculous. If the mine is in the shooter's full view, that man is in grave danger from shrapnel splinters.

Next comes the suggestion to destroy

the mines with fire. Experience has proven this is very wrong, indeed. In one incident, a pit was dug and a number of mines placed in it and liberally covered with petrol and lit. Once again it proved 75% ineffective for two reasons. (1) The explosive was partly protected by the metal bodies, sensitive detonators packed in the centers of the mines, in the fuses. The result was that one of the fuses was damaged and when the debris was turned over the mine went off and the metal casings became dangerous shrapnel.

These practices are very dangerous and must not be entertained at any cost. It is far better to stack mines requiring destruction, marking them as such and reporting them to the proper authorities.

The easiest way to destroy mines, or one mine, is by using a primer, detonator and a substantial length of Safety Fuse to give a delay. When dealing with one mine, uncover without disturbing it, and place sandbags around it. Finally, place a primer in the center of the lid, complete with detonator and fuse. Carefully cover with loose earth, leaving the fuse showing. When the primer is initiated it supplies sufficient blast to actuate the mine, just as if a vehicle had passed over it.

This method applies to single mines requiring on site destruction, but where mines can be moved, they should be carefully stood on one end, in a shallow trench 18" deep, with the lids towards the center. A primer, detonator and a length of safety fuse is then placed in between the center mines, the lids of which should be facing each other. The primer provides sufficient blast power to actuate these mines, which in turn, set off the remainder.

Various other methods were devised to clear mined areas in the early stages of the desert war. Among them was one which entailed the use of a "mat" or "net", woven with primacord and unrolled over a mined area and then initiated simultaneously at several points. This proved almost useless, because the blast power was insufficient to actuate a deeply laid mine.

Recently, a device known as the "Conger" was tried out. This consists of a length of 2" canvas hose, which is projected empty over a minefield by means of a 5" rocket and subsequently filled with a liquid explosive known as 822. It is capable of clearing a 25 foot lane through a field of TMI 42 & 43s and it promises to be very effective.

The mine sweeping tank was very successful in clearing paths through minefields in Normandy. But it is not an entirely new idea. Originally a vehicle was used, with two steel girders projecting in front and a roller, fixed so that its protruding steel spikes dug into the ground as the vehicle moved forward and the weight of the roller actuated the mines.

Unfortunately, the roller, being made of concrete, could not withstand the continuous blasts of the mines and it was soon shattered. Consequently, the idea was temporarily abandoned, until the "flail mechanism" was thought of some time afterwards. The first model, called the "Scorpion", was constructed by fitting the flail mechanism to the "Matilda Tank", the mechanism being driven by an auxilary engine.

Further types were the Baron Marquis and Crab. The latter drives the cylinder by the tank engine, and as it rotates, lengths of heavy chain attached to it act as flails. They beat the ground with considerable force, exploding the mines in its path.

The latest type is fitted with a Sherman chassis, shortened in length and breadth. Its main armament is a 75 mm gun. It has "feelers", which give warning of obstacles and Bangalore Torpedo ejectors, which eject the torpedos to destroy the obstacles and clear a path.

The drawbacks to this type of mine clearance are few. But one was found to be the fitting of a thicker shear-pin to the TMI Z .42, so that the flails failed to shear it and operate the igniter. Consequently, the tank tracks were shattered by the mine, disabling the mine-clearance tank.

A second idea, very uncommon, was to link a Tellermine by a detonating fuse to a charge, so that when the mine was actuated by the flails the charge was set off, disabling the tank once more.

These special devices to defeat the purpose of this special tank, requires special preparations, also. And in the present stage of the war on the continent, owing to the mobility of the troops, it is not possible to anticipate any move with a sufficient margin of time to lay counter-measures against the use of the "Crab" tank.

This method is not in full use in the Far East. The country does not lend itself to mine warfare, except of course, anti-personnel mines. But nev-

ertheless, personnel undergoing training in methods of mine clearance should anticipate the Japanese use of mines whenever the opportunity presents itself.

METHODS OF GERMAN MINE LAYING.

The object is not to teach actual laying and lifting of German minefields. It is to teach general recognition and warn you of methods employed to defeat detection and lifting. It is generally understood that the Germans are a thorough and methodical race, but also prone to repetition and, in spite of their thoroughness, sometimes fail to carry out their original intentions, leaving tell-tail clues which are equally as important as mines, fences and warning boards themselves.

Although his minefields are ofttimes fenced in, when he retires, he removes all traces possible and one has to rely on mines-signs to detect their presence. There are however, two types of minefield marking recently discovered:- The first is the more common of the two and consist of two rows of warning boards, the outer, black & white lettering and the inner, white and black lettering.

The space in between the rows of boards is normally clear of mines. The second consists of lengths of barbed wire wound around the post. A/P mines are indicated by a 3" length projecting from the top of the post, wheras A/T mines are indicated by two dome-like hoops on the top of the posts, giving an appearance similar to a mine marker. Ofttimes it has been found that the front edge of the minefield has been left entirely unmarked, and if marked, false gaps and deceptive wire has been found or encountered. There may also be scattered groups of mines laid haphazardly in front of the minefield, which are entirely unmarked.

Belts of mines, laid close to our own forward defense localities may also be seen, as they are often hastily laid. Ofttimes machinegun and listening posts are placed well forward of main minefields, and are covered by automatic sentries, consisting of Very lights operated by trip-wire. Naturally A/P mines are laid to the best advantage, this being mainly in front of the minefield, although it is common to find them in the field itself.

To give the minefield an appearance of depth, shallow mine belts are sometimes employed, with considerable gaps in between, and consisting of 2-5 rows each. Normal distance between mines and rows is 5-10 yards. These narrow belts help to hide gaps. They are normally up to 270 yards long by 20 yards deep.

Booby-traps, connected to wire obstacles, are operated by the movement of the obstacles. Or else, by movement of some other object in the field to which they may be attached and which is in range

The entire layout of a prepared minefield is coordinated with a fire plan of defense, so that a deficiency in mines is made up by firepower.

Approximately 25% of the Tellermines laid are booby-trapped. Occasionally, during retreats, additional charges were laid under the Tellermines. These were attatched to the anti-lifting devices. These charges were either 75 lb. boxes of TNT or 200 gram blocks of Penthrite or Tolite. As much as three 75 lb. boxes have been laid under a treble Tellermine making a total charge of 261 lbs., capable of completely destroying vehicles.

Tellermines have also been found laid at 2 yards spacing, closely spaced deliberately to cause "Sympathetic Actuation". No cases of "dummy" minefields have been reported to date. But there was one instance where a field of "Holtz" mines (German wooden box mines) were found to be dummies, as these mines were found to be filled with sand. This, however, was thought to be sabotage.

Very few patterned minefields were found, but A/P minefields were found on hill terraces, accessable normally only to personnel. High grass or grainfields afford excellent covers for breast-high trip-wires or lever actuated mines, besides the normal pressure-operated mines.

To defeat the detector, A/T mines have been found laid as deep as 2'6" so that vehicles will eventually compress the earth hard enough to actuate the mines. One instance of mines laid below their normal depths revealed that groups of six were laid 18" to 24" deep spaced approximately one yard from the road centers and where single mines were laid deeply, they were spaced 20-50 yards apart. Holes in the roads, which ran through or near a mined area, were sometimes filled with scrap metal, and other times a mine was laid deeply, with scrap metal on top to cause a delay. Other cases revealed an unbroken road surface, but mines had been laid under the tarmac surface from the side of the road, so that the passage of vehicles would cause the surface to crumble.

When approaching a minefield, remember that it is very easy for the enemy to trip the outer from your side without causing any damage to enemy troops who may advance through their own minefield. This is done by running a wire from the outer wire to a pull action switch outside the minefield so that the leading elements of your own troops who are advancing towards an enemy position, set the trap off and it kills or injures others behind:

The only snag to this type of booby-trap is that enemy troops returning from patrol activity in our lines, may accidently operate it and suffer casualties- "Serves them right".

Here is some information recently obtained from Italy.

A/P Fields.

In theory, mines are always laid in regular patterns by a pacing drill, evenly spaced so that alternative rows cover off the spaces left by other rows. Density for shrapnel mines: 1 mine per meter. Minefields with a density of 1 mine per meter were never deeper than 25 meters (approx..27 yards) and with a density of 1/2 mine per meter, maximum depth is 40 meters.

Spacing.

Between mines, 4 meters maximum 10 meters, with never less than 4 rows or more than 7 rows at 8-10 meter intervals.

Mixed Fields.

There was a tendency to lay pairs of rows of one type alternately with pairs of others.

Marking.

A german A.P. minefield always has a trip-wire on its enemy side (facing us), which should be 2 meters from the nearest row of mines. Back corners are always marked with stone cairns (mud piles otherwise) in line with the trip-wire with no other signs to indicate A.P. mines.

Gaps.

Personnel gaps (1/2 meter wide) marked with extra signs such as white tape, handkerchief, white paper or a cross-piece of wood. A single low wire running transverse to the line of the field is the boundary between "blocks" laid by different units. 1/2 meter on either side of these wires is always safe.

The ends of the minefield are unmarked unless close to a road or track, and then by a trip-wire along the road. These observations do not apply in all instances, or when mines are laid in haste.

Anti-tank mines.

In theory, these are laid out in regular patterns and staggered from row to row. The density is 1-5 mines per meter of front, and the spacing and interval not less than 10 meters: Anti-tank mines, as previously remarked are sometimes separated from A/P only by the boundary trip-wires. But there are normally no markings left except a fence or wire by the road.

One instance was recorded where holes had been dug and filled in again, giving the appearance of a minefield. But this could hardly be called a dummy minefield, but a decoy minefield.

Anti-tank ditches, although deep and wide, can be crossed by personnel and to prevent this, shrapnel mines are laid in the bottom, also the bottoms of slit trenches.

Another instance of an anti-personnel minefield found is as follows:-

Bayonets were driven in the ground so that they protruded six inches above-ground.Fine trip-wires ran to mines midway between bayonets. Concrete picket mines were used in bush or scrub, with the concrete cylinders one inch above ground-level. There was very little attempt at concealment, either in this case or in the following one:-

Trip-wires led to a ZZ .35 igniter screwed in a 200 gram block in company with two others, buried 2" to 3" below ground-level. Neither of these instances was classed as successful.

So ends my course on methods employed by Germans in laying their mines. It must be understood that the subject is one upon which it is possible to continue investigation indefinitely, as these methods change daily as different types of country are encountered. But remember, "Forewarned is Forearmed", and by keeping your eyes open you may save your life and others.

To gain further expertise in the deadly skill of mines and booby-traps, study THE IMPROVISED MUNITIONS HANDBOOK, PMJB 2, page 282; MINES AND BOOBY TRAPS, PMJB 3, page 11. BOOBY-TRAPS, page 235 and INCENDIARIES, page 274.

CONTINUED FROM PAGE 1

the extent that they also packed it in.

The Germans in their Russian campaign were similarly demoralized by partisans who cared less than nothing for German military prowess or technology. Aside from pitched battles with Russian regulars or siege tactics around major cities, the German soldier was helpless and alone outside his encampment. Most towns on the route were either destroyed or bypassed. They were too dangerous to occupy.

The French partisans were so effective at sabotage and the murders of German personnel as to necessitate vast amounts of extra manpower and equipment throughout France. And the French government had capitulated and promised its people would be nice!

Our own ancestors probably killed more British regulars by ambush and sniping than in pitched battles.

Over the ages, irregular warfare has advanced from sniping, ambush and simple sabotage to refinements undreamed of by our ancestors. But the end purpose has remained the same. That is, to so harrass, confound and confuse an enemy that he can't function. And wheras former irregular warfare has been only a complement to regular troops, the Viet Cong and the Afghan Freedom Fighters won their wars with it.

As world civilization degenerates and the mass dieoffs accelerate, we will face a series of invasions. Possibly by Russians but certainly by hordes of Latin-Americans, fleeing starvation and plague as their own countries cease to be nations. Then the U.S. will become a vast battleground of urbanites fighting each other for another day of life

Towns will be ringed with defenses against refugees and renegade military units.

No one can really know what will actually happen, but if you prepare for the worst you can defend your own against all comers. And in preparing, you must drop the macho fantasies and study the martial art of improvised weaponry.

Of course, a basic part of your study must be conventinal light weaponry. The 1883 gunsmithing course in PMJB 3 is something to cut your teeth on. You can also make money reconditioning antique guns.

Clyde Baker's 1933 gunsmithing course will update your skills. You will also be surprised at how the science of ammunition in Earl Naramore's 1937 HANDLOADER'S MANUAL will enlarge your expertise on explosives.

By reading every paragraph in all four volumes of THE POOR MAN'S JAMES BOND, you will absorb knowledge subconciously, even though you might not fully understand it all at the first reading. Then, when you are most needed, you will be one of the most important men in your territory.

FM 21-105

BASIC FIELD MANUAL

of

ENGINEER SOLDIER'S HANDBOOK

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BASIC FIELD MANUAL

ENGINEER SOLDIER'S HANDBOOK

(This manual supersedes FM 21 105, March 12, 1941.)

CHAPTER 1

THE ENGINEER SOLDIER AND THE CORPS OF ENGINEERS

■ 1. WHAT IT MEANS TO BE AN ENGINEER.—You are an engineer. You are going to build bridges and blow them up. You are going to stop tanks and destroy them. You are going to build roads, airfields, and buildings. You are going to construct fortifications. You are going to fight with many kinds of weapons. You *are going to make sure that our own troops move ahead against all opposition, and you are going to see to it that enemy obstacles do not interfere with our advance. You are an engineer.*

■ 2. YOU AND YOUR JOB.—a. You have been chosen to be trained to do a man-sized job for the Army and for your country. To do it well you must keep your eyes and ears open, your mind alert, and be always on your toes. You must keep yourself in top-notch condition. You must become physically tough and an expert at your job. Whether or not our Army succeeds depends a lot on how much better *you* are at *your* job than the *enemy* engineer is at *his*.

b. That's a large order. The Army knows it is; but the Army also knows that if you give the best that is in you, you will do the job well. You will build, tear down, and fight better than any other soldier in the world. You will be an *American* engineer.

■ 3. THE CORPS OF ENGINEERS AND THE FIGHTING TRADITION.—a. *The beginnings of the Corps of Engineers.*—(1) The Corps of Engineers to which you belong has a long record of courage and of jobs well done. The early engineers set high standards of achievement; the engineers who came later in our history not only maintained those standards, but even improved upon them. Today you and your fellow engineers are carrying on that record, you are going to make the history of the Corps of Engineers even more brilliant.

2 2–3

(2) The first engineers were three small companies organized in the Revolutionary War with the help of French officers. The job of engineers then consisted mainly of constructing field fortifications. The act of the Continental Congress which created the engineers stated that its commissioned officers were "to be skilled in the necessary branches of mathematics; the noncommissioned officers to write a good hand." Those requirements are a long way from the numerous skills our soldiers must have today, let alone our officers and noncommissioned officers.

(3) In 1802 an act of Congress created the present Corps of Engineers. Until the Civil War there was only a handful of engineer troops in our Army. Even during the Civil War the largest number of engineers was four companies. But engineers performed valiant tasks. They fought as infantry in courageous fashion. The engineering jobs of that little body of men should make us proud to carry on their tradition, for example, they threw a 2,000-foot pontoon bridge across the James River in a few hours. That's a mark for us to shoot at.

b. *The development of the Corps.*—(1) Engineers continued to play important roles in every military campaign in our history. It wasn't until the first World War, however, that the great force of engineer troops was really felt. In that war the Corps of Engineers grew from 2,500 men to almost 300,000. The way they fought and did engineer work at Cantigny, St. Mihiel, and Meuse-Argonne is one of the magnificant traditions of the Corps

(2) Today you are part of hundreds of thousands of troops who make the Corps of Engineers a constructive and destructive fighting force. The chapters which follow will tell you something about the numerous jobs of engineers; they will help prepare you to carry on the important missions of the Corps of Engineers.

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CHAPTER 2

ENGINEER TOOLS AND COMMON ENGINEER TASKS

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SECTION I

ENGINEER TOOLS

■ 4. IMPORTANCE.—a. The engineer soldier is an expert in many things. One of his most important skills is the use of many kinds of tools, some, hand tools, others, power tools Tools are the basic implements of the engineer They go along with his unit and are always at hand. With tools the engineer accomplishes many tasks How well and how quickly he does his job depends upon—

(1) His skill.

(2) His physical condition.

(3) The condition of his tools.

b. All of these are the responsibility of the individual soldier. His own life and the lives of his fellow soldiers depend upon the tools and the skill with which they are used.

■ 5. CARE.—Mainly upon you, the soldier who uses these tools, depends the condition of the tools. When the supply sergeant or his assistant issues tools to you, you become responsible for them. Clean and oil them before you return them. If you are careful in the use of your tools, if you use them in the correct manner, if you are quick to notice and report such things as dullness, battered heads, and rough spots on handles, the job of keeping tools in good condition is easy.

■ 6. SAFETY.—Your tools are sharp. If they are handled improperly you or a comrade may be hurt. Learn to use your tools correctly; the correct way is both the easiest and

4 6–9

the safest way. Here are a few general safety rules. Do not forget any of them

a. Carry your tools properly. (See fig 1.)

b. Do not lay sharp tools such as axes, adzes, and peavies, on the ground where they can be stepped on, fallen on, or run into

c. When swinging a tool make sure all others are a safe distance away.

d. Make sure all tool heads are tight on their handles.

e. Do not get in the way of another soldier who is using a tool.

■ 7. USE.—Tools are designed to do work with a minimum

of effort. The untrained man tires himself by forcing his tools, gripping them too hard, or using an improper position. The trained man is relaxed, lets his tools do most of the work, and uses his mind, eyes, and hands to guide the tools.

■ 8. ENGINEER TOOL SETS.—Each engineer organization is equipped with the hand tools needed for accomplishing the work usually assigned to it. For convenience in selecting tools for a particular job, they are grouped into sets, such as carpenter, blacksmith, pioneer, and demolition sets. Learn to know the contents of the various squad and platoon sets.

■ 9. HAND TOOLS.—Most of the tools you use are hand tools, the most important of which are discussed below. These discussions are only a guide, however; they are not a substitute for actual training and extensive practice. Apply the things you read here at the first opportunity.

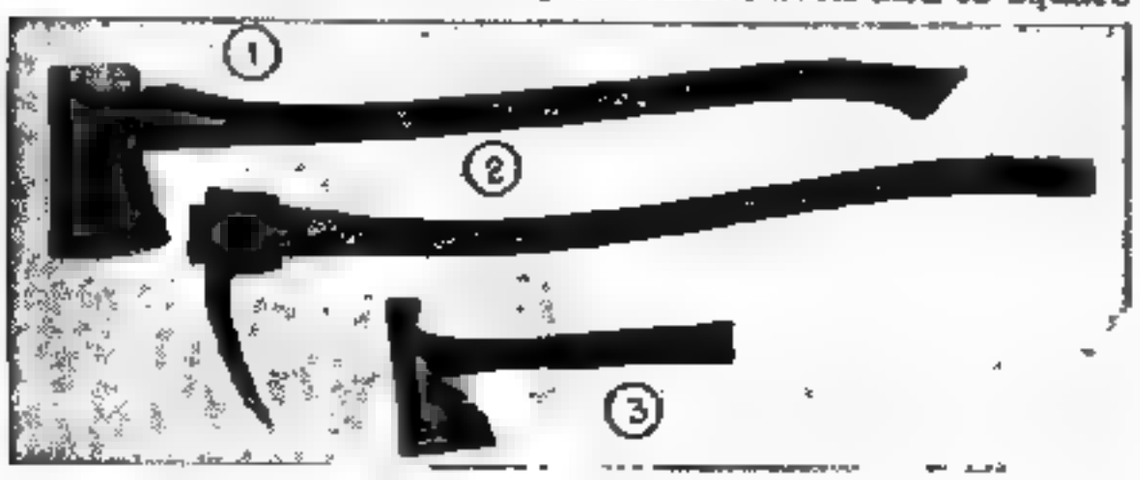
a. Ax (see fig. 2).—Before starting to swing the ax, make sure that there is no interference in any direction. If there are overhanging limbs or undergrowth in the way, clear them out first. Make sure of a firm footing and see that no one is dangerously close. In swinging the ax, be especially careful to stand so that if the mark is missed, or if the ax glances off, it will not strike you. (See figs. 3 and 4.) Keep your eyes on the point to be struck. Never throw the ax or leave it lying on the ground; instead, drive it into a log or stump, or put it in its box. Never use the ax to drive metal stakes.

① ⑨

FIGURE 1.—Proper way to carry ax, adz, and two-man crosscut saw.

b. Hatchet (see fig. 2).—The hatchet is used for light trimming work such as framing timber, sharpening stakes, or splitting wood. The position of the hand depends upon the desired blow. Hold it near the end of the handle to strike a heavy blow for heavy cuts and near the head for light trimming strokes. The hatchet has a hammerhead which may be used for driving medium-size nails.

c. Adz (see fig. 2).—The adz is a hewing and smoothing tool used by engineers mainly to remove bark and to square

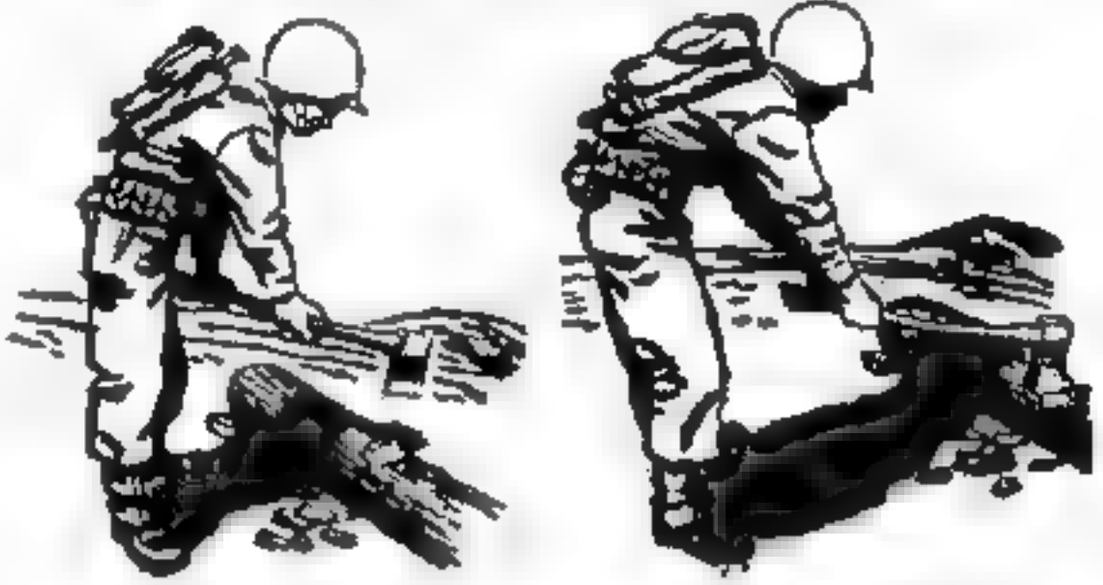


① Ax. ⑧ Adz. ③ Hatch

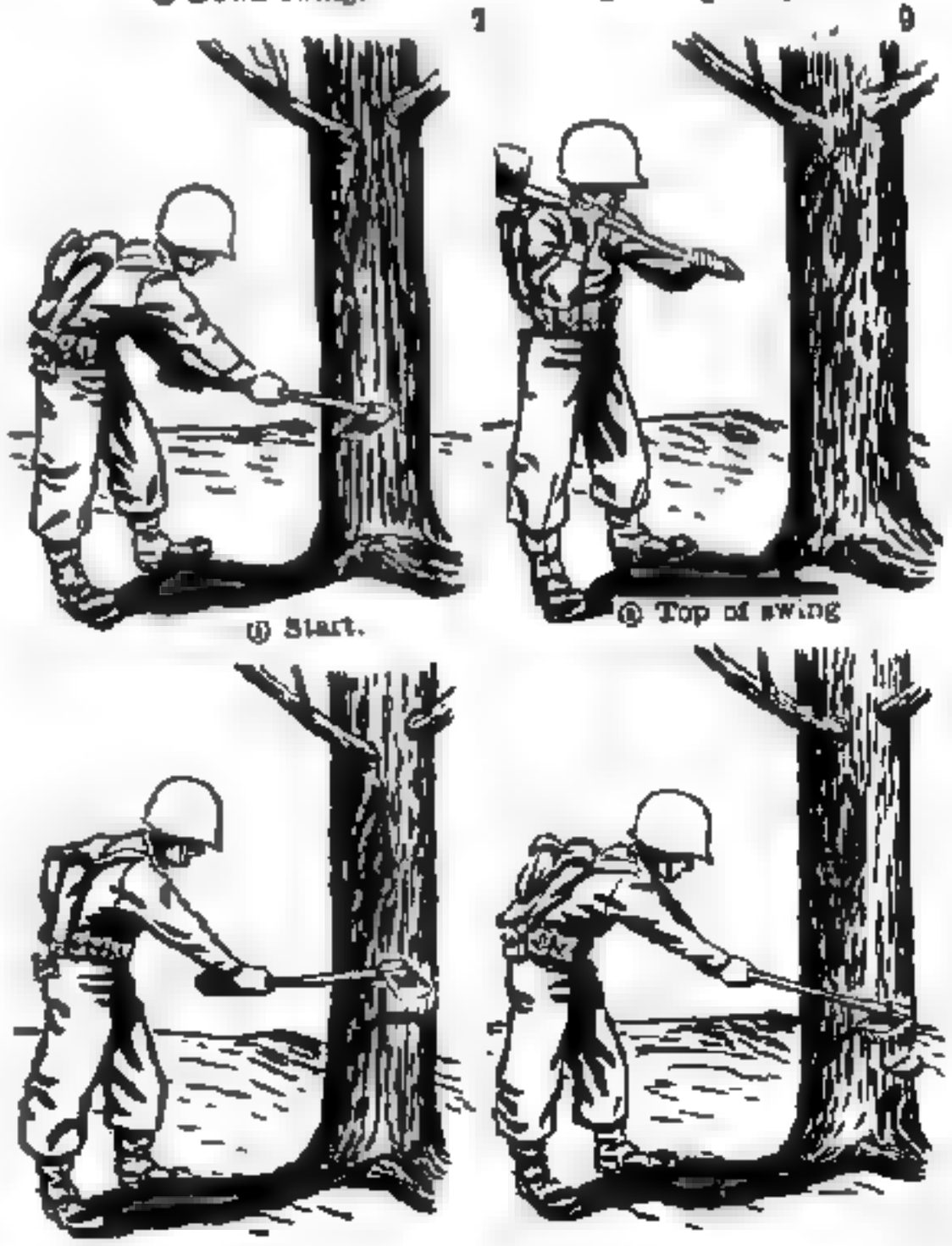
FIGURE 2.—Hewing tools.

⑥ ⑨

FIGURE 3.—Using the ax on horizontal timber



④ Down swing. ⑤ Swing completed.



④ Start. ⑨ Top of swing

⑨ Down swing. ④ Swing completed.

FIGURE 4.—Using the ax on standing timber

round timber. It must be used carefully or the user may be injured. The correct way to use the adz is to stand astride the log and take short hewing strokes. (See fig. 5.) The log is first scored with chopping strokes, or with shallow cuts made with a saw.

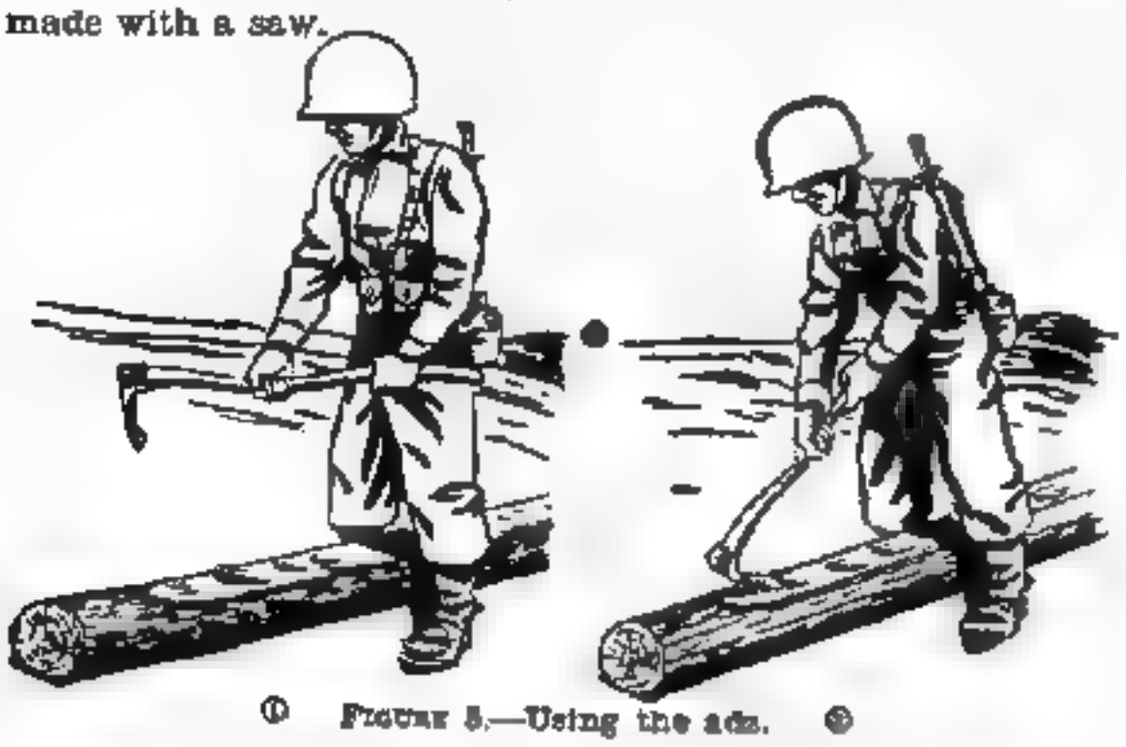


Figure 5.—Using the adz.

Figure 6.—Pick.

d. Pick and pick mattock (see fig. 6).—You should be able to use the pick or pick mattock with either the right or left hand leading. The pick is swung in a manner similar to that used in swinging the ax. (See fig. 3.) To use it with the right hand leading, stand with your feet comfortably placed, left hand at the handle end, right hand near the pick head, body bent slightly forward, and arms hanging naturally. Carry the pick head behind and above your right shoulder without changing the position of your hands. Swing the pick head forward, allowing the handle to slide through your right hand until your hands meet, and continue the stroke downward. Keep your eye on the point to be struck.

e. Shovels (see fig. 7).—You should be able to use the shovel with either a right- or left-hand swing. After filling it by one of two methods (fig. 8 ① or ②), press the handle down and back to free the shovelful from the rest of the material. Then hold the handle down while raising the weight of the full shovel with the other hand. In casting, allow the handle to slide through the lower hand in the most convenient manner. Do not use a shovel as a pry.

f. Saws.—Saws are of various design, depending upon the kind of work required.

(1) *Hand saws* (fig. 9①).—There are two kinds of hand saws—crosscut and rip. A crosscut saw has knifelike teeth and is used to cut wood *across* the grain. A ripsaw has chisellike teeth and is used to cut wood *with* the grain. The hand saw is used in most common carpentry work. A saw cut should be started by guiding the blade against the thumb of the left hand and drawing the saw backward (fig. 10).

Extending the forefinger along the handle aids in guiding the blade. Hold the saw lightly and do not try to push it into the wood; move it back and forth with a full, long stroke, letting it do its own cutting.

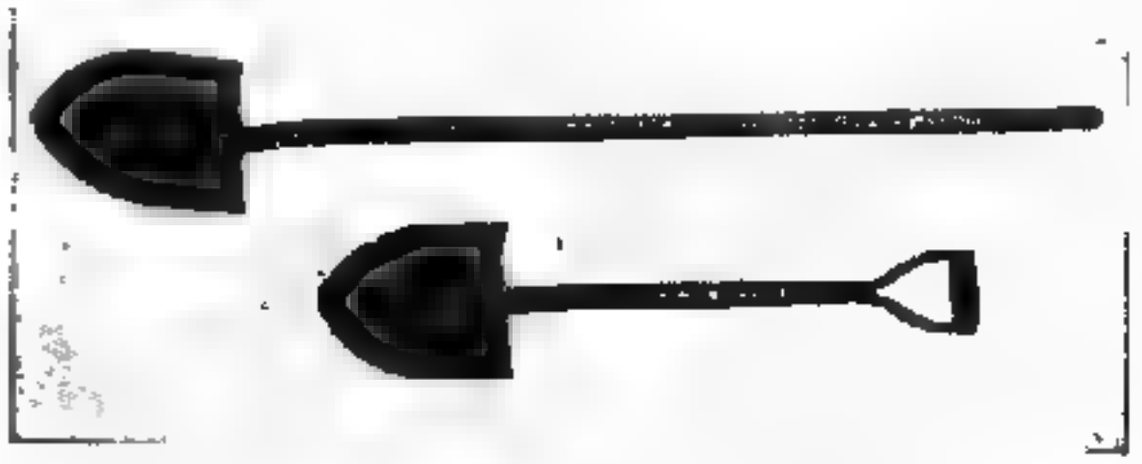
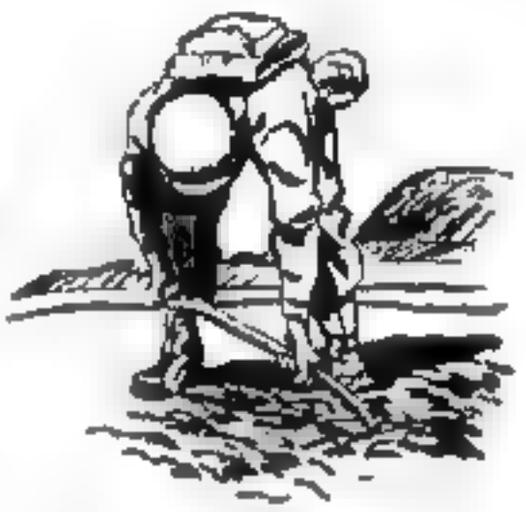


Figure 7.—Long-handled and D-handled shovels.

① Filling shovel.



② Filling shovel (alternate method)

③ Start of throw

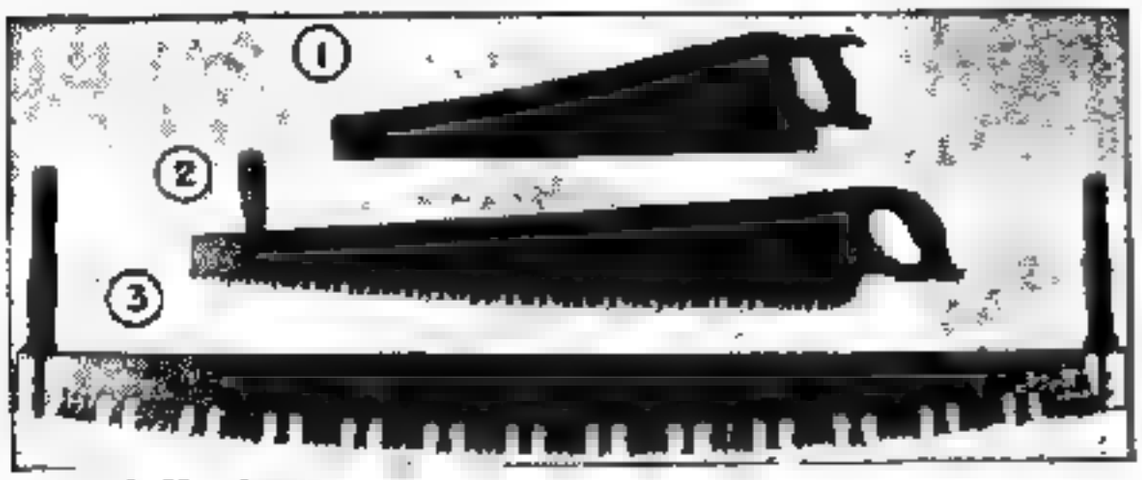
④ End of throw

Figure 8.—Using the shovel

(2) *One-man saw* (fig. 9 ②).—This saw is equipped with cutting and drag teeth and an extra handle so that, if desired, two men (one at each end) can use it. This saw is used on fairly heavy and rough timberwork where speed is more important than close fits or exact measurements.

(3) *Two-man crosscut saw* (fig. 9 ③).—This saw has two removable handles and is used for cutting standing trees or for heavy framing or cutting. Two men operate it by pulling alternately. Do not push or "ride" the saw; one man's straight pull does the work while the other man relaxes but keeps his hand on the handle.

g. Claw hammer.—The claw hammer is used to drive and draw nails. In driving nails, the hand should be at the level



① Hand saw
② One-man crosscut saw with supplemental handle.
③ Two-man crosscut saw

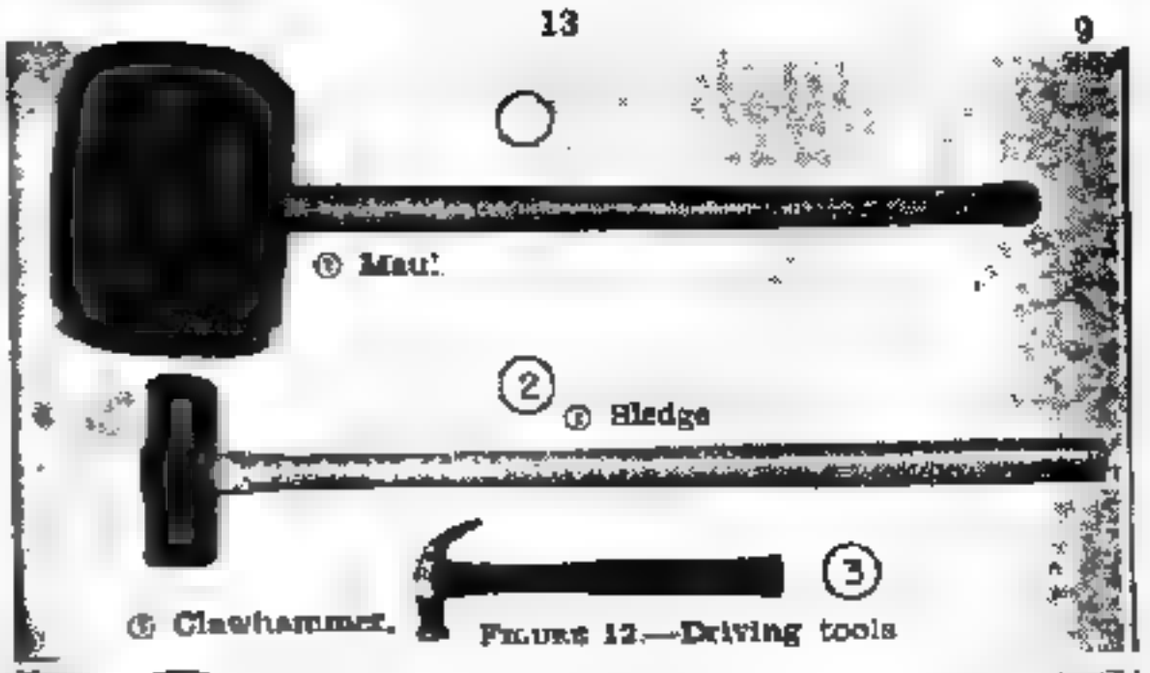
FIGURE 9.—Saws.

of the nailhead at the moment of impact so that the nail is hit squarely and the force of the blow travels directly along the nail. (See fig. 11.) Similarly, in drawing nails, the force should be directly along the nail, as shown in figure 11.

h. Sledge (see fig. 12).—The sledge is used for heavy driving, rock-breaking, striking rock drills, and for shop and general construction work. It should be swung like a pick. A full stroke gives best results.

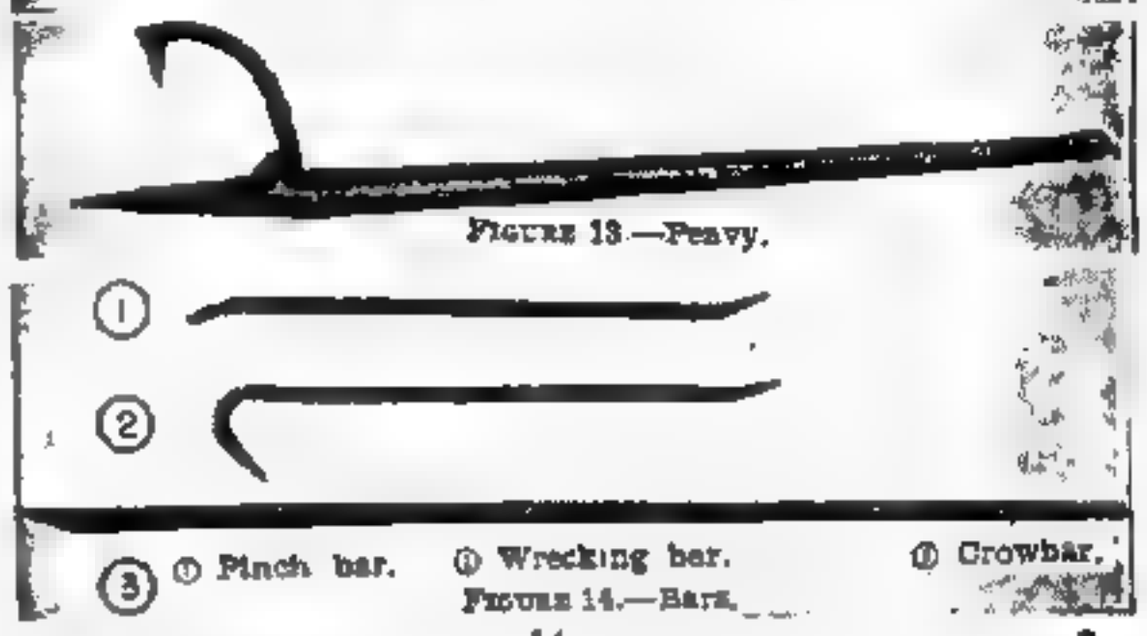
i. Maul (see fig. 12).—The maul is a heavy, wooden driving tool, and should be used only to drive wooden stakes and posts. It is swung like the sledge.

j. Peavy (see fig. 13).—The peavy is a gripping and leverage tool, used to roll, haul, or carry heavy timber. To carry heavy logs with pearies, men should be distributed equally on each side of the log. (See fig. 40.)



④ Maul.
⑤ Sledge
⑥ Clawhammer.

FIGURE 12.—Driving tools



① Pinch bar. ② Wrecking bar. ③ Crowbar.

FIGURE 14.—Bars.

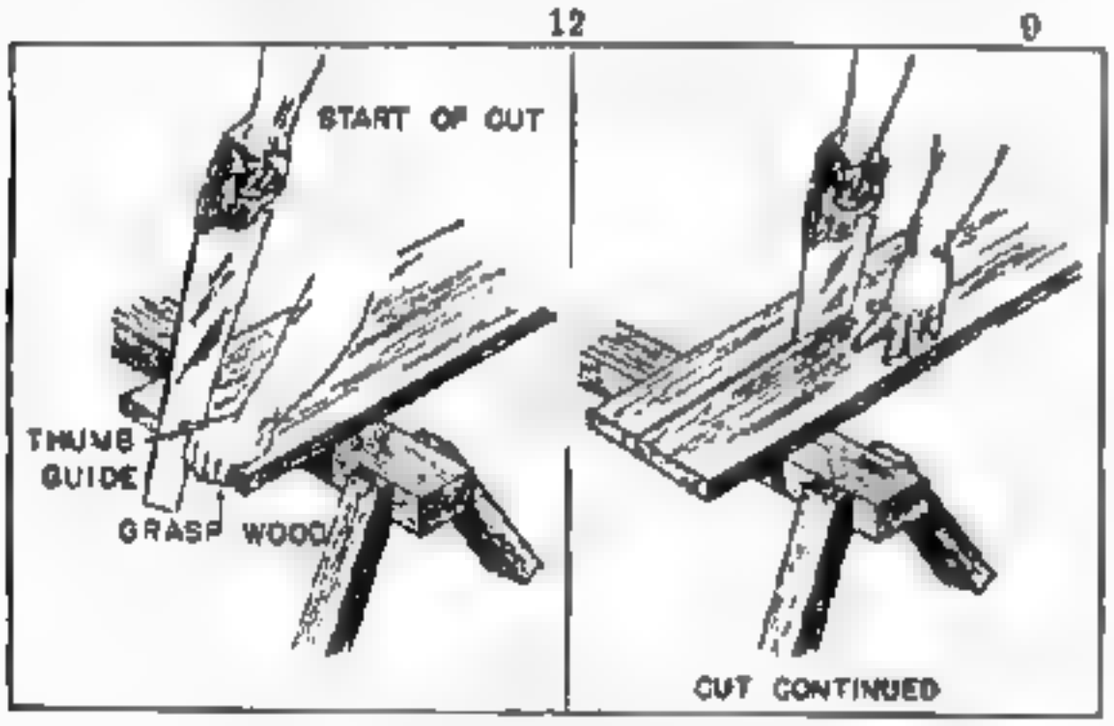


FIGURE 10.—Using the saw

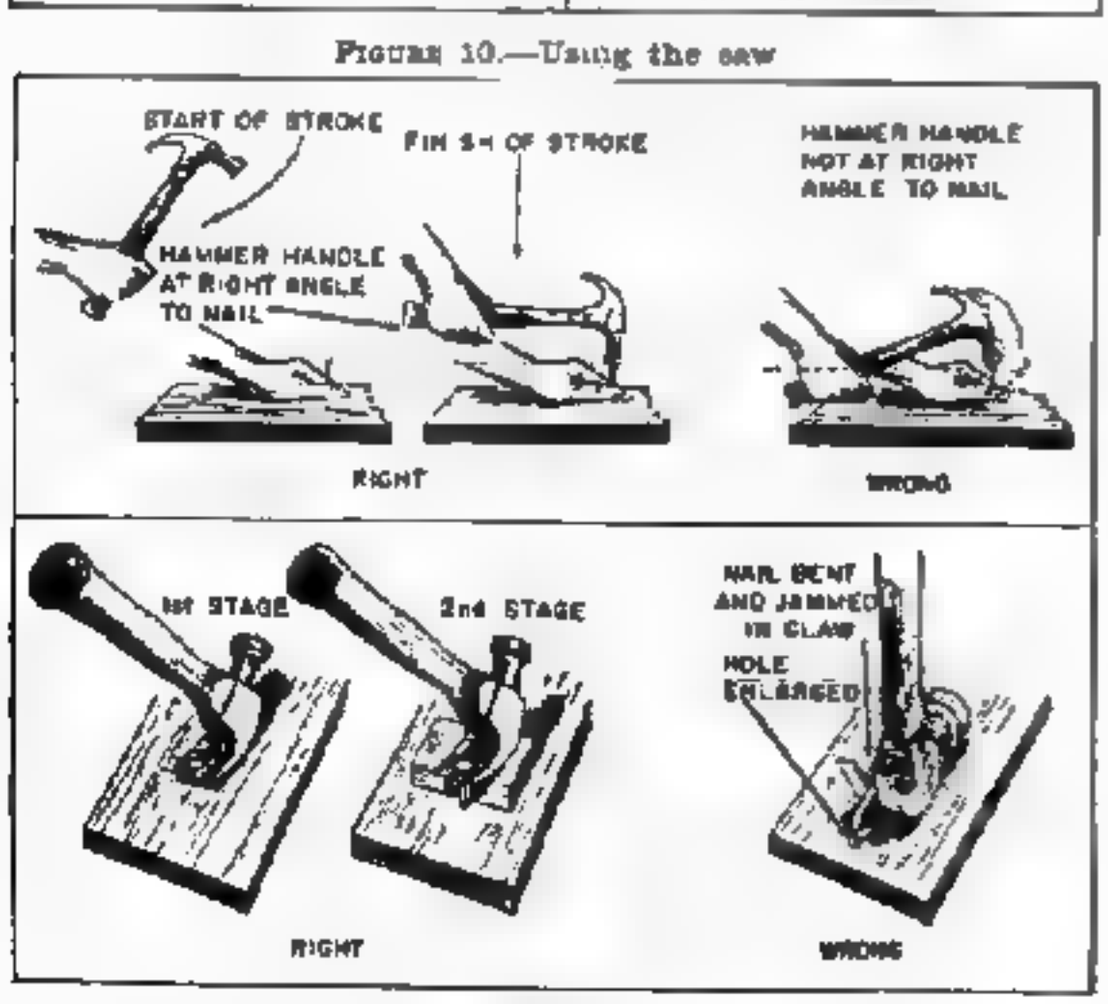


FIGURE 11.—Using the hammer

k. Bars (see fig. 14).—There are several kinds of bars, of varied shapes: crowbar, wrecking bar, pinch bar. These are prying tools and are used as levers. In using these bars, secure as much leverage as possible and take small "bites" each time. Be satisfied with relatively small movement at the cost of little effort, instead of doing excessive work to make a large move.

l. Brush hook (see fig. 15).—The brush hook is a sharp curved cutting tool used to clear underbrush and to trim branches. It should be swung with both hands at the handle [redacted].

m. Machete (see fig. 16).—The machete (pronounced muh-SHAY-tay, muh-SHET-ee, muh-SHET) has a long, extremely sharp blade with a wooden handle. It is used to clear underbrush and trim small branches. It is swung with one hand. Keep it in its sheath when not in use.

n. Earth auger (see fig. 17).—The earth auger is an extremely useful hole-boring tool for the engineer. The 6- and 10-inch sizes are most commonly used. As far as possible, keep the cutting blades out of contact with rocks; use it with care in rocky ground.

o. Wire cutters (see fig. 18).—Wire cutters are especially designed to cut barbed wire. The rubber-covered handles are insulated against live wires. The bent hooks on the searching nose are used to pull the wire toward the operator. The cutters are used with two hands.

p. Side-cutting pliers (see fig. 18).—Side-cutting pliers are used both for holding and cutting, essentially with one hand.

q. Pocketknife (see fig. 19).—The pocketknife has four blades, which include a combination reamer and leather punch blade, a screw driver and bottle-opener blade, a can-opener blade, and a cutting blade. It is equipped with a clevis for attachment to a carrying chain, thong, or cord.

r. Wrenches (see fig. 20).—The two chief adjustable wrenches are the monkey wrench for angular bolts or nuts,

and the pipe wrench for round fittings. Note the differences between them.

15 9

s. Brace and bit (see fig 21).—The brace and bit is a boring tool with a variety of bit sizes. It has different bits for wood-boring and for metal-boring. Make sure the wood drills do not come into contact with foreign material such as rocks and nails.

t. Ship-ring auger (see fig. 22).—The ship-ring auger is a long boring tool used to bore holes deeper than those made with the bit and brace.

FIGURE 15.—Brush hook

FIGURE 16.—Machete and sheath

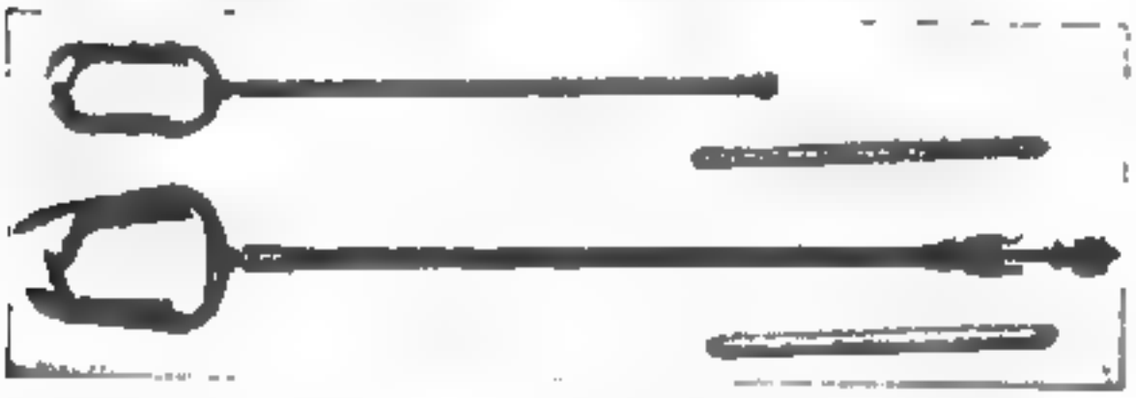


FIGURE 17.—6- and 10-inch earth augers.

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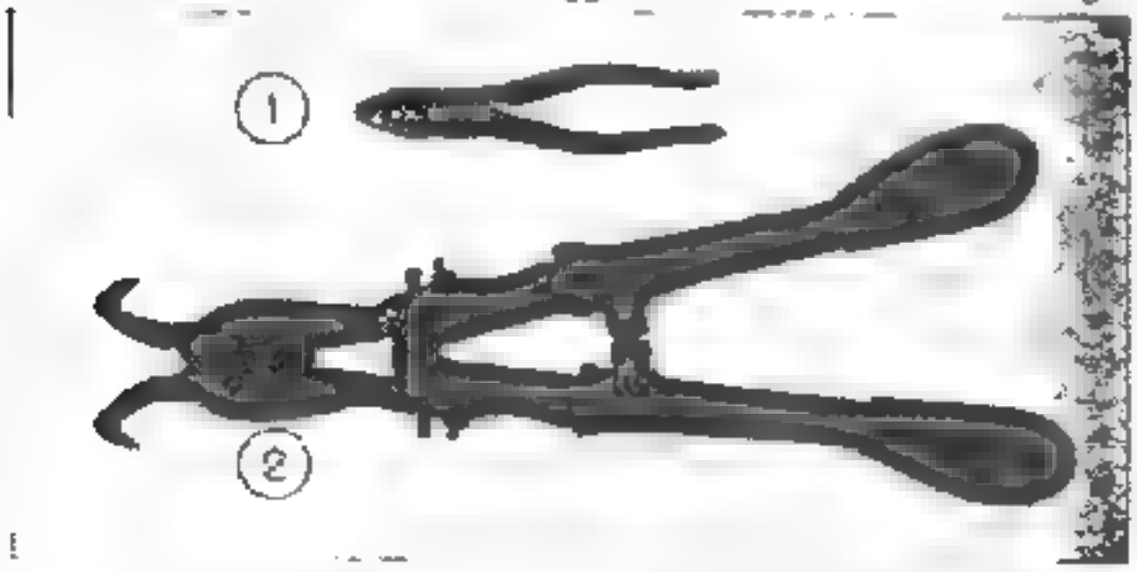

① Wire cutters ② Side-cutting pliers.

FIGURE 18.—Wire-cutting tools.

u. Plane (see fig. 23).—There are several kinds of planes used for various kinds of work, but the working principle of all is the same. It is a smoothing tool with a fine cutting blade. It should be used with both hands guiding the stroke. Take long easy strokes with the grain of the wood, short strokes against the grain. Be especially careful that the blade is not nicked by nails or other obstructions in the wood.

v. Chisels (see fig. 24).—(1) Wood chisels are struck with a wooden mallet, never with a metal hammer.

(2) Cold chisels for cutting metal are struck with metal sledges and hammers.

w. Measuring tapes (see fig. 25).—The standard engineer measuring tape is a metallic, linen-fiber tape, rolled in a leather case. Keep it in its case when not in use. Since the

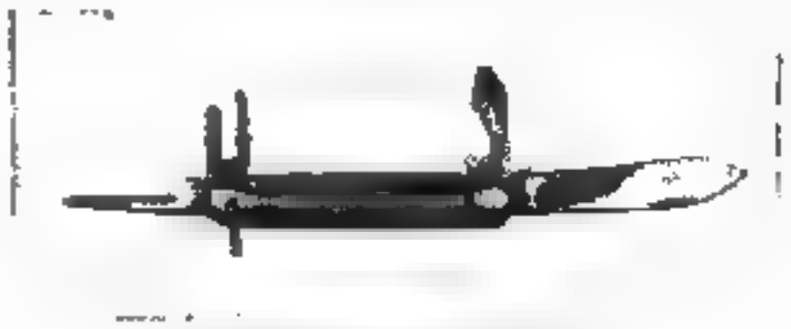

FIGURE 19.—Pocketknife

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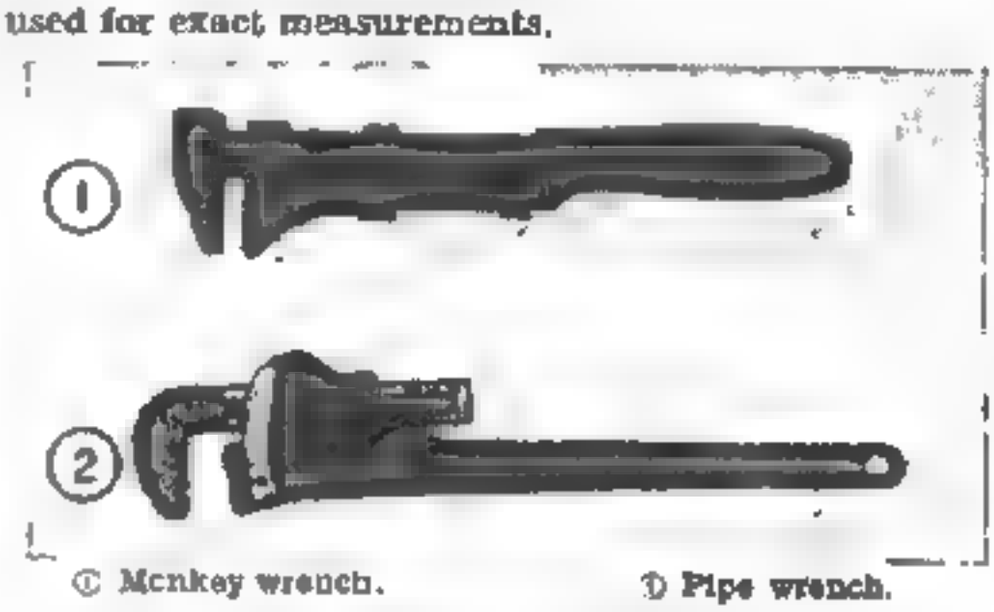
metallic tape stretches slightly, the 6-ft. steel rule should be used for exact measurements.



① Monkey wrench. ② Pipe wrench.

FIGURE 20.—Wrenches.

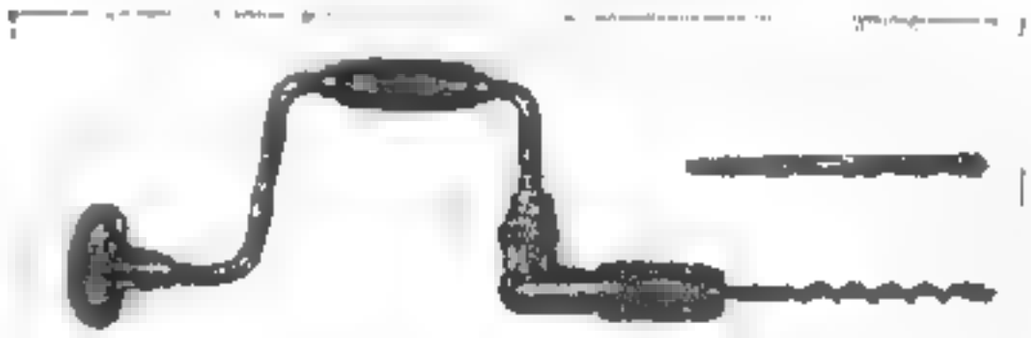


FIGURE 21.—Brace and wood bit, with detached steel-cutting bit.

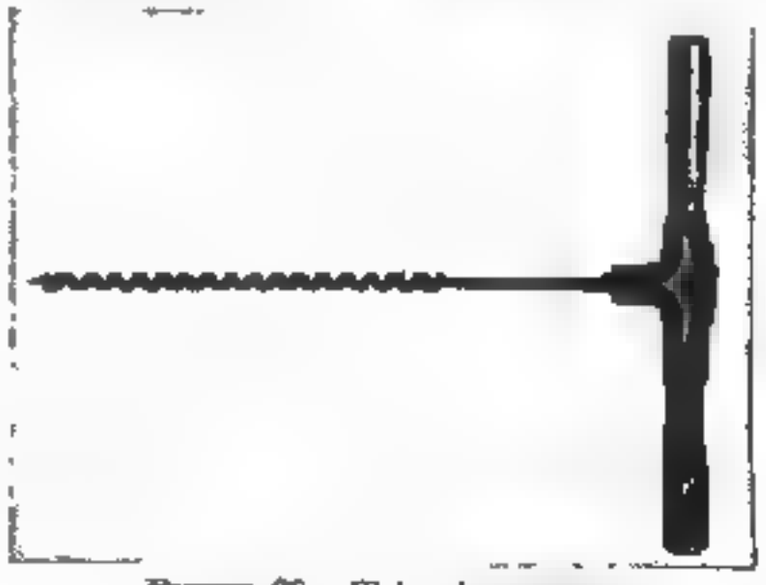


FIGURE 22.—Ship-ring auger

FIGURE 23.—Jack plane

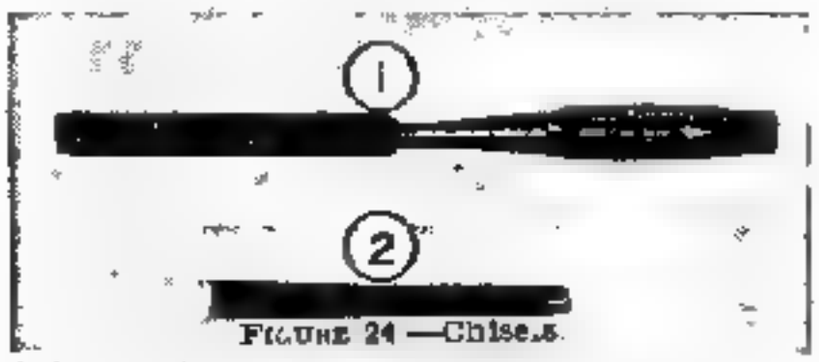


FIGURE 24.—Chisels.

① Wood chisel. ② Cold chisel.

① Metallic tape. ② Steel rule.

FIGURE 25.—Tapes.

x. Squares (see fig. 26).—The try square is used to test square edges and surfaces. The steel framing square is used to measure angles and to draw the various lines needed by a carpenter.

y. Level (see fig. 27).—The level is a precision instrument. By means of the bubble (bead) in the phials in the level, the engineer can determine whether or not a surface is horizontal or vertical. When the level rests on a surface and the bead is centered in the tube, the surface is level.

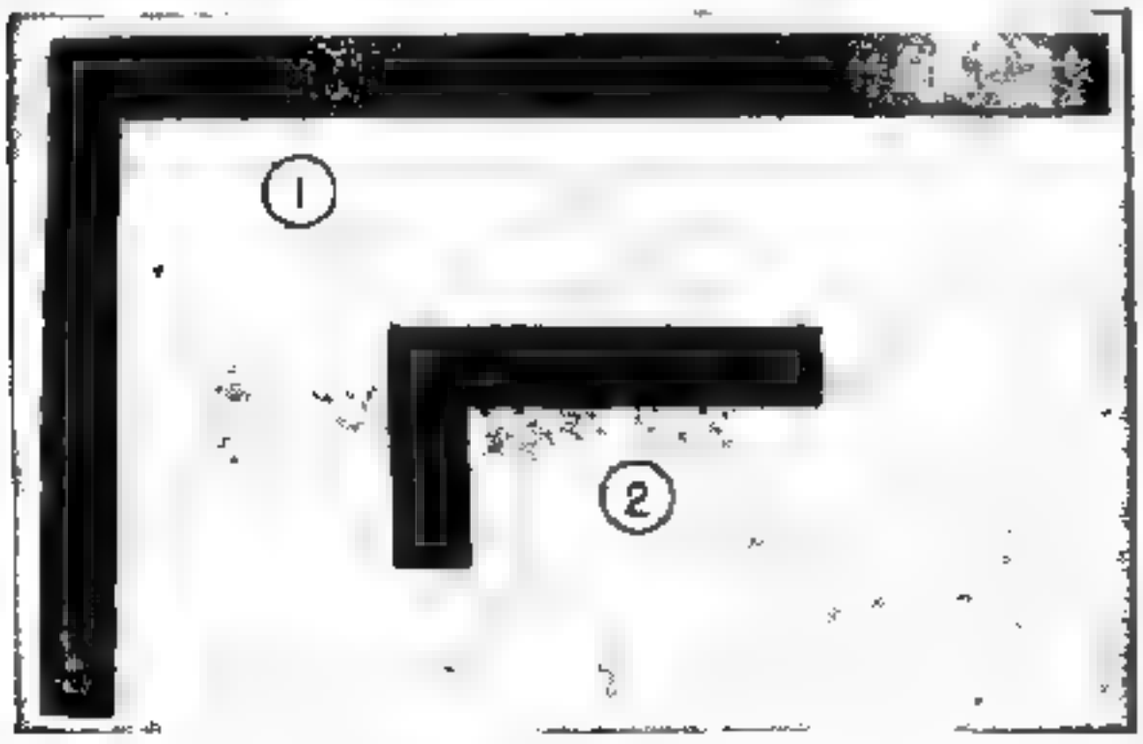
19 10-11

■ 10. POWER-DRIVEN TOOLS.—The power-driven tools used most frequently by the engineer are tools driven by compressed air from the mobile air compressor unit. These tools save much time and labor, and each engineer soldier should know how to use them. The tools most commonly used are clay diggers, wood and rock drills, pavement breakers, hammers, and wood saws (See figs. 28 to 34, inclusive.) Figure 35 illustrates the gasoline timber saw.

SECTION II

COMMON ENGINEER TASKS

■ 11. MATERIALS.—Certain prepared building materials, such as standard-size lumber, are available to engineers at supply depots. However, very often the engineers must build their bridges, emplacements, etc., out of local materials found at the site of the work. Therefore, an engineer soldier must be always alert to note local materials, resourceful in his use of these materials, and quick to use them whenever he can.



① Carpenter steel square. ② Try square.

FIGURE 26.—Squares.

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FIGURE 27.—Carpenter's level.

FIGURE 28.—Pneumatic clay digger with spade and moil-point attachments.

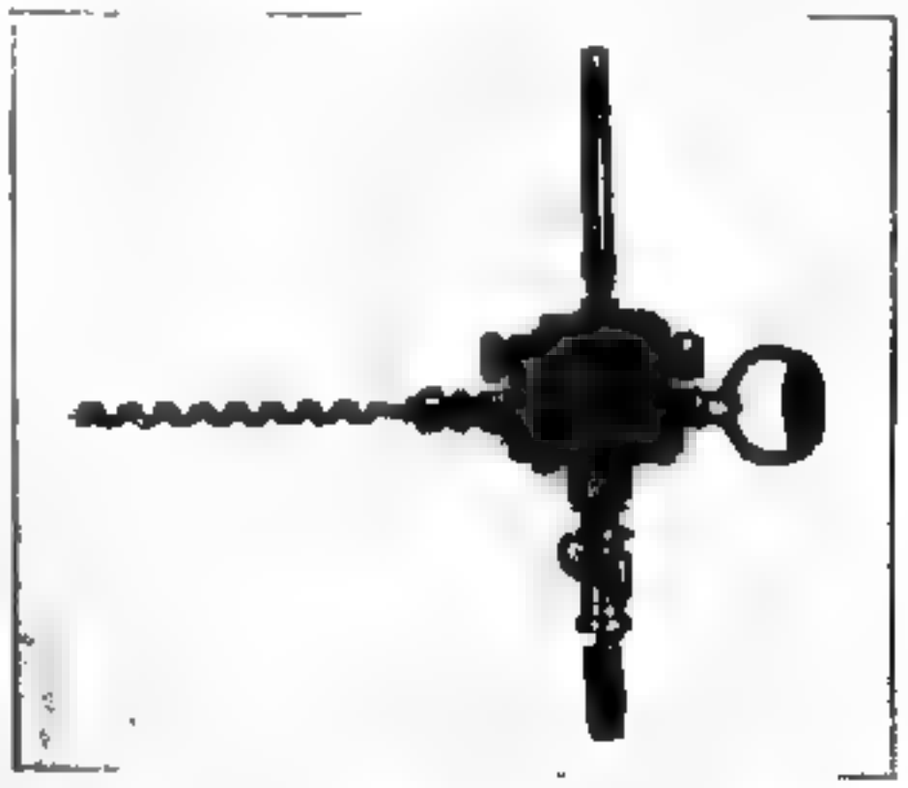

FIGURE 29.—Pneumatic wood drill.

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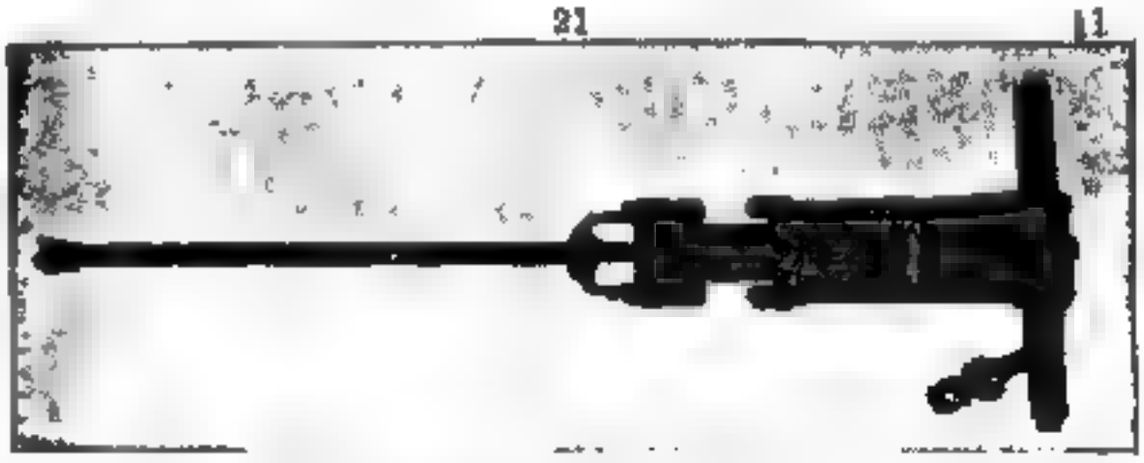

FIGURE 30.—Pneumatic rock drill.

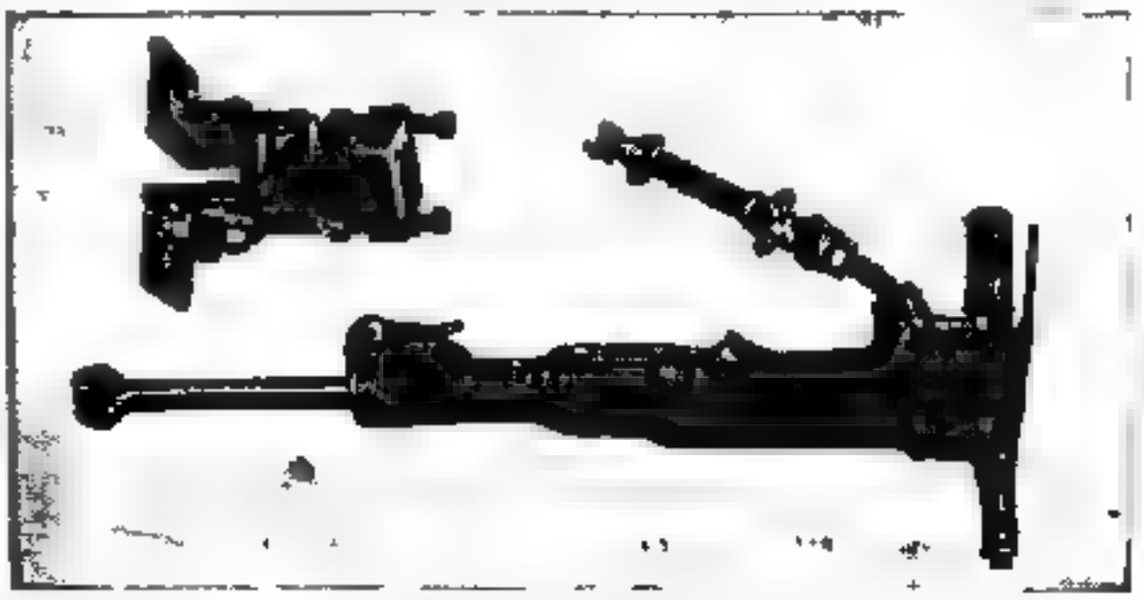

FIGURE 31.—Pneumatic pavement breaker with sheathing-driver attachment.

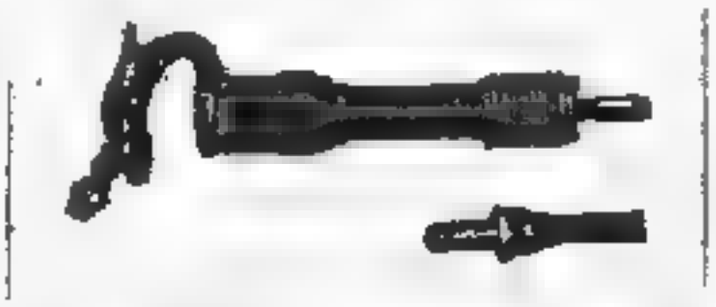

FIGURE 32.—Pneumatic nail driver with chisel attachment.

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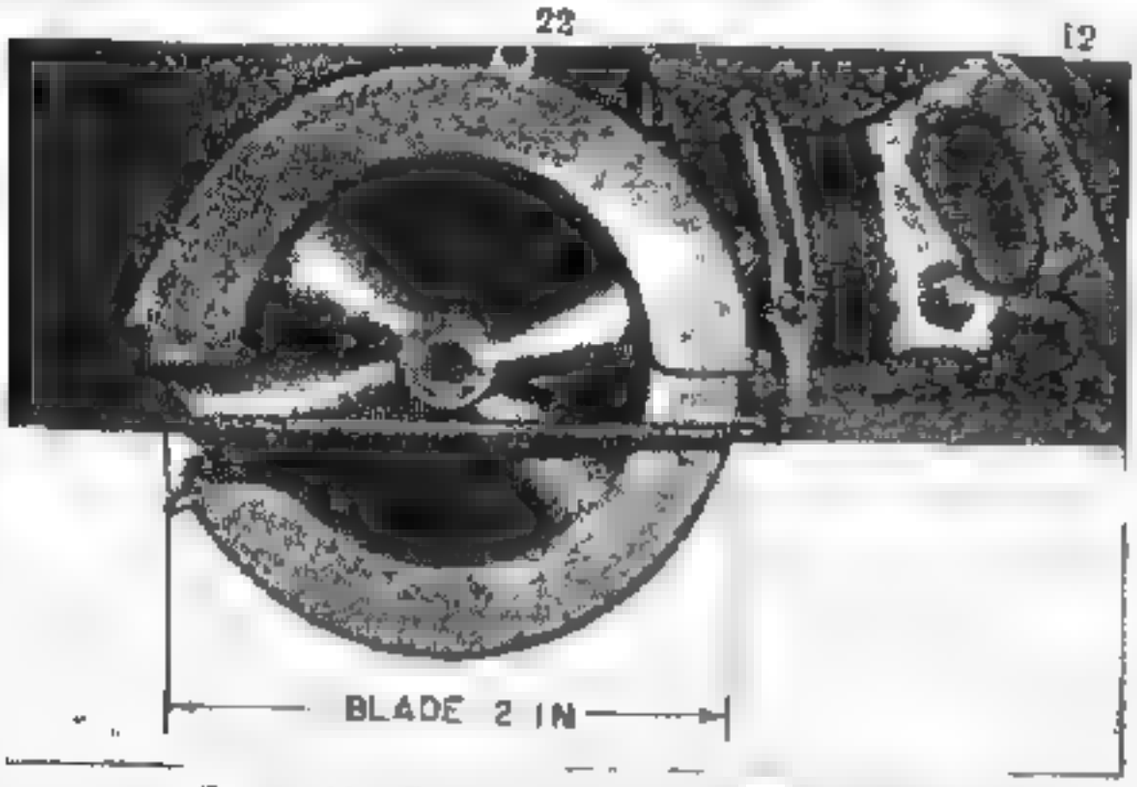

FIGURE 33.—Pneumatic circular timber saw.

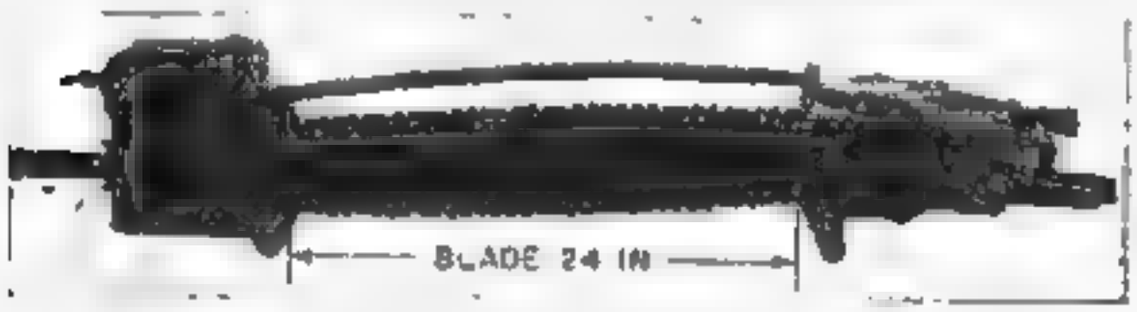

FIGURE 34.—Pneumatic chain saw

■ 12. FELLING TREES.—With an ax, cut a deep notch near the base of the tree (see fig. 38) on the side toward which the tree is to fall. Then saw the tree on the opposite side to cut the remaining fibers, using steel wedges, if necessary, to keep the saw from binding. To cut the trunk clear of the stump, the saw cut should be started opposite the point of the notch. Where it is desired to keep the base of the tree firmly attached to the stump after felling, as in making a tree road block, the saw cut should be made considerably higher than the notch, so that all fibers will not be severed when the trunk falls. It is often advisable to use guy lines

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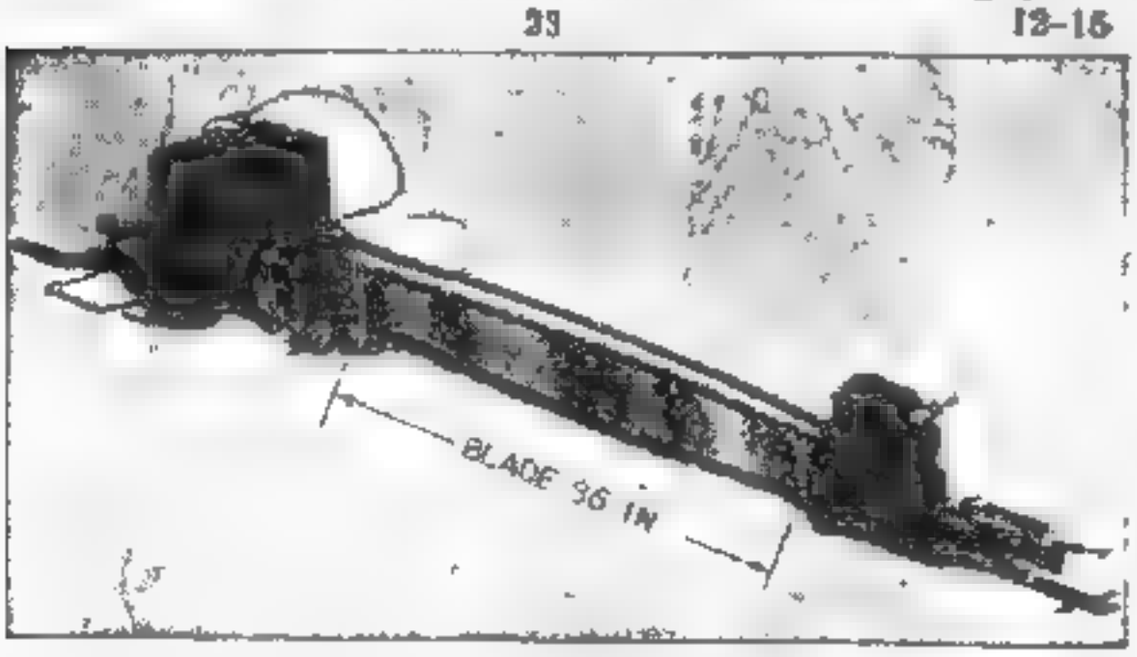

FIGURE 35.—Gasoline-driven chain saw.

to guide a tree in falling and sometimes to use hand or motor power to pull a tree in a desired direction.

■ 13. MAKING TIMBER JOINTS.—In rough carpentry work, the butt joint and the lap joint are used to join or splice two pieces of wood so that they form one continuous piece. (See fig. 37.) The butt joint requires the use of fishplates to hold the ends together. The lap joint is made by overlapping the ends of two timbers and nailing them together. This is the simplest and quickest splice for bracing and like uses.

■ 14. DRIVING DRIFTPINS.—Driftpins (heavy iron spikes) are used to fasten large timbers together. Since driftpins are made of relatively soft iron, holes must first be bored in the wood before the pins are driven. These holes should be slightly smaller in diameter than the pin itself; for example, the hole for a ½-inch driftpin should be made with a 7/16-inch bit.

■ 15. HANDLING LOADS.—*a. Heavy lifts.*—The proper method of lifting heavy loads is to make the legs do the work. (See fig. 38.) Do not bend over from the waist and throw all the strain on the groin and back muscles. Improper methods of lifting often cause a hernia (rupture).

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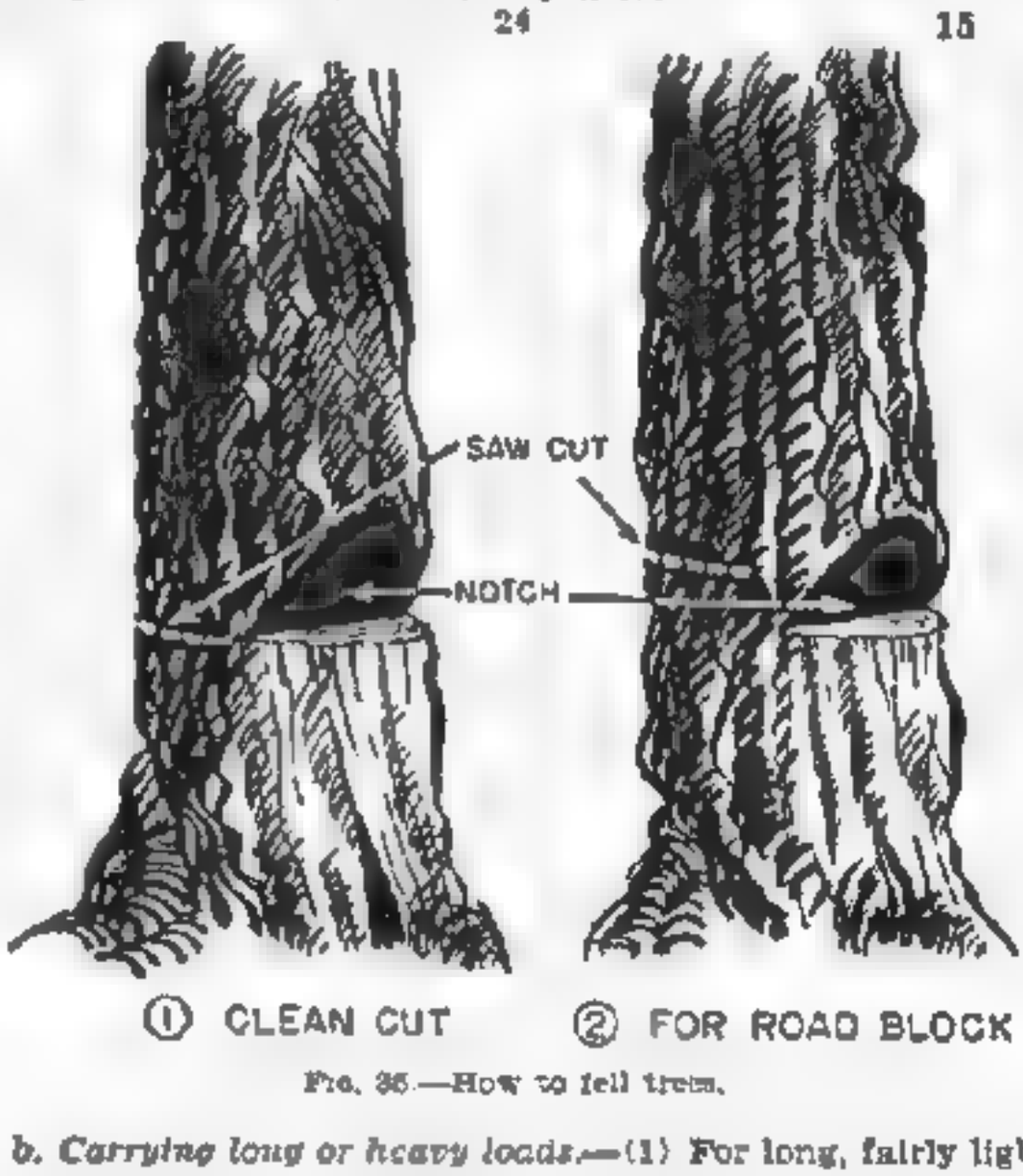

FIG. 36.—How to fell trees.

b. Carrying long or heavy loads.—(1) For long, fairly light objects, such as timber beams or ponton bulk, one man takes each end; to keep it from tipping over, the load rests on the right shoulder of the man in front and on the left shoulder of the man in the rear. (See fig. 39.)

(2) For carrying somewhat heavier objects, more men may be used in a similar manner, but it is better to use pick handles, pipes or bars of ample length placed underneath. Two men (on opposite sides of the load) carry each handle. Timber and rail tongs, if available, should be used in the same manner, except that the load hangs below the handles. Figure 40 illustrates the use of the peavy to carry timber. Extremely heavy loads should be handled on pipe rollers, wheeled dollies, block and tackle, or by machines.

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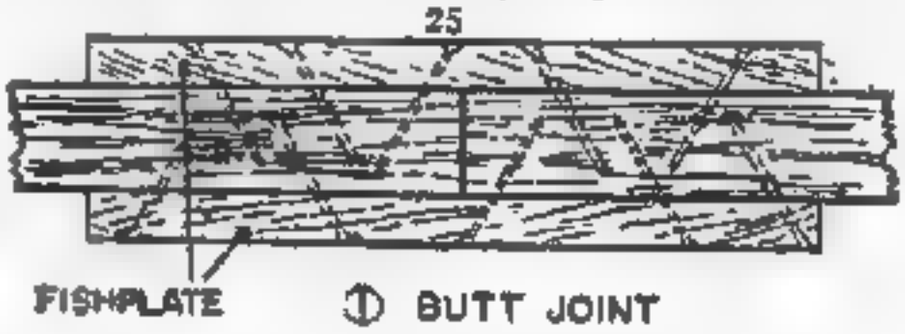
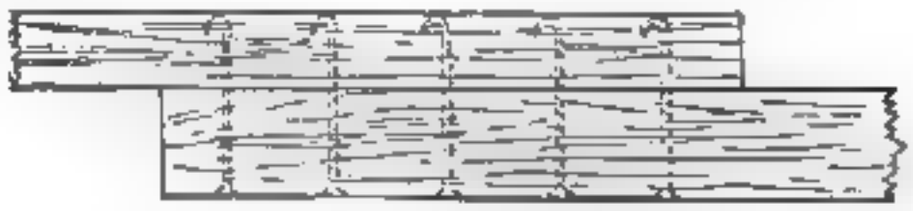
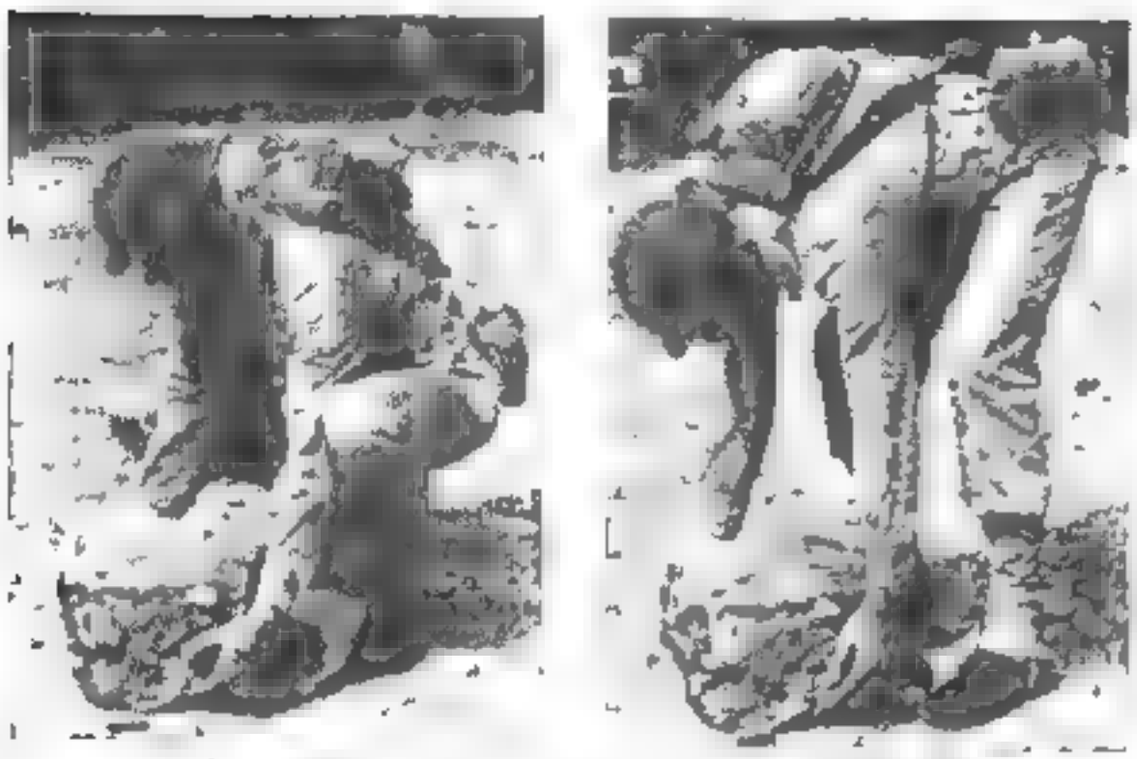




② LAP JOINT

FIG. 37.—Simple timber splices.



① Right. ② Wrong.

FIG. 38.—How to lift heavy objects

26 15–16

(3) For small but heavy loads, a wheelbarrow should be used with the load placed evenly as far forward as practicable.

c. Carrying chess.—A wide one-man load, such as plank or 10-ton ponton chess, is carried on edge, rear end down, next to the body, with the right hand underneath, near the middle or balance and the left hand on top steadying and guiding the load. (See fig. 41①.) Sometimes, when the chess is unusually muddy and slippery, or when fatigue necessitates the use of two supporting hands, the chess may be carried with both hands underneath. (See fig. 41③.) When this is done, however, special care must be taken to control the plank so that no one is hit by the ends. For carrying 25-ton ponton chess, two men are needed.

FIGURE 39.—Carrying balk.

■ 16. USING SANDBAGS (see fig. 42).—Sandbags are always laid with the chokes (mouths) tucked under and the side seams and tied ends inside. Grain, cement, and similar

27 16

bags can be used, but they should not be more than half-filled or they will be too heavy for a man to handle. Sandbags are used frequently as reveting material to bolster the sides of holes in the ground. Figure 42 shows various ways to use sandbags for revetments. To lay sandbags properly, they must be shaped so that when in place they are roughly half as wide as they are long.

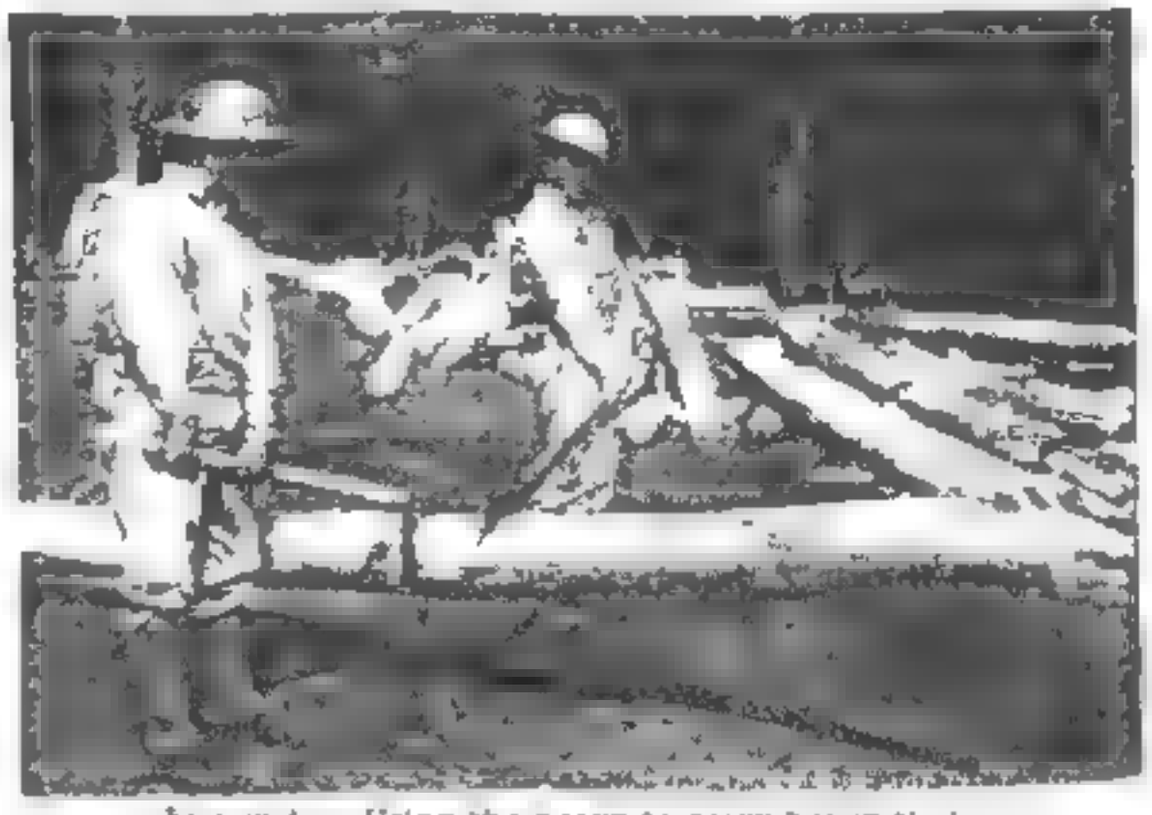
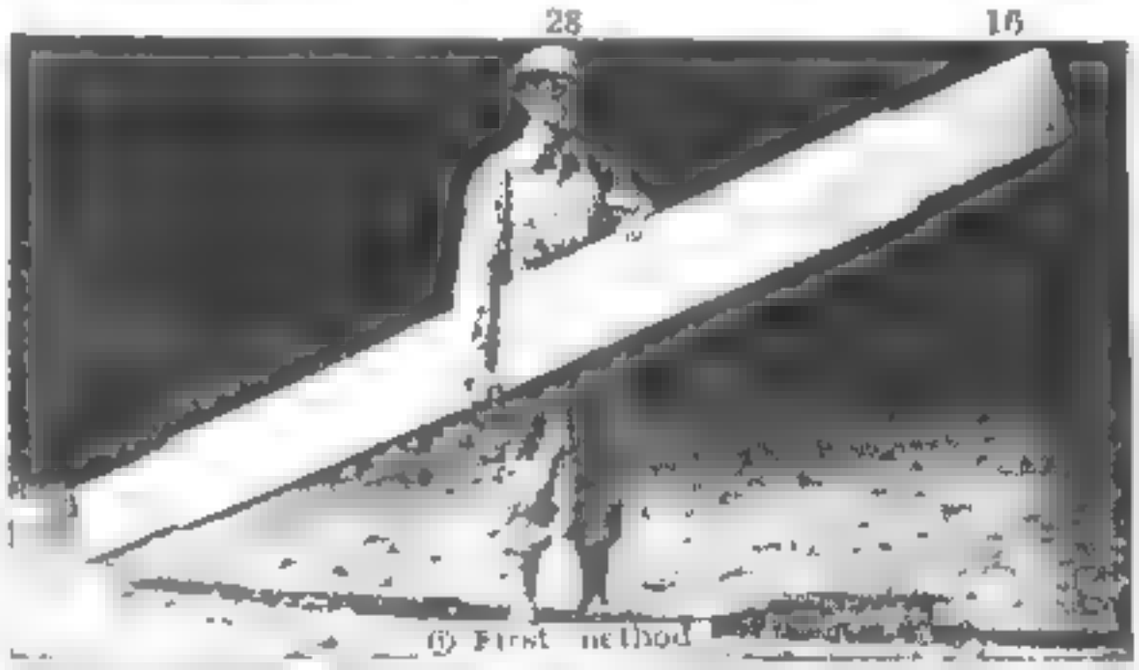


FIGURE 4.—Using the peavy to carry heavy timber.

28 16

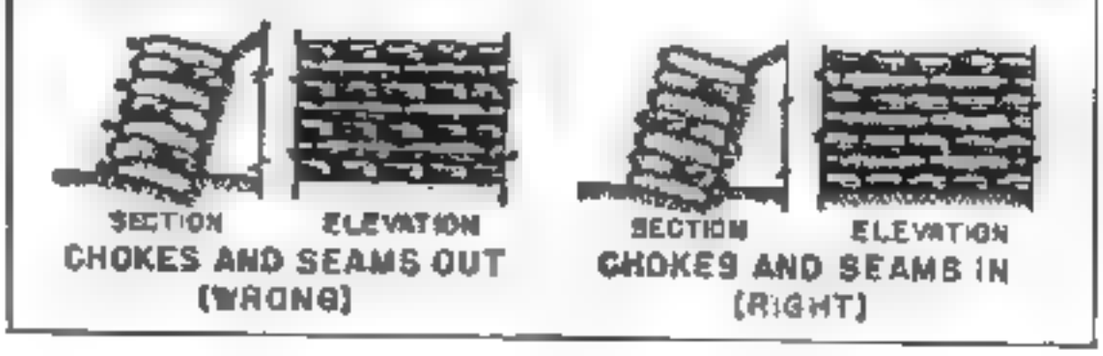


① First method

② Alternate method.

FIGURE 41.—Carrying 10-ton ponton chess.

29 16



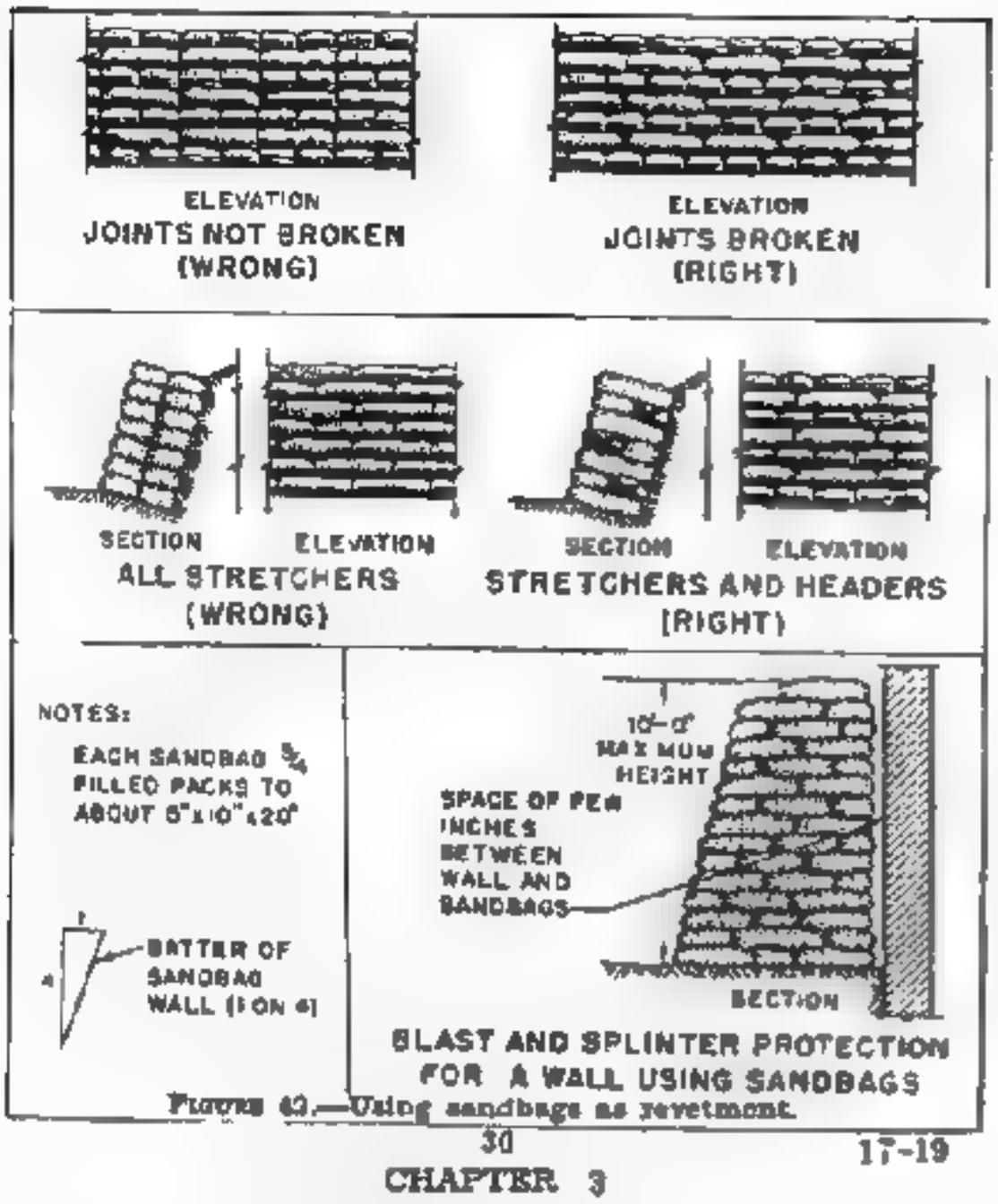


FIGURE 43.—Using sandbags as revetment.

30 17-19

CHAPTER 3

ELEMENTARY RIGGING

■ 17. IMPORTANCE.—The engineer often makes his own machines for use in heavy work and as substitutes for tools and machines that are unavailable. The machines are simple, but they save much labor. By "rigging" is meant the handling of rope (manila or wire) and chains with blocks and tackles to raise, move, or hold heavy loads. The combinations which the engineer rigs up with rope are really simple machines. This chapter explains the principles and methods of rigging, which will be one of your most valuable skills as an engineer. Make a thorough command of this skill a part of your personal Army knowledge.

■ 18. CARE OF ROPE.—Proper care of rope lengthens its usefulness. Observe the following precautions.

a. Do not store in wet, damp, or hot places.

b. Clean muddy rope by washing in water

c. Dry before storing but do not use artificial heat.

d. Avoid pulling over sharp edges.

e Avoid dragging rope through sand or dirt. Sand has an abrasive action on the inner fibers.

f. Keep rope free of contact with acid, alkali, or other damaging chemicals.

g. Use knots that can be untied and will not have to be cut.

h. Repair broken strands as soon as possible.

i. Slacken dry, taut lines when exposed to rain or damp weather.

j. Always whip loose ends of rope, and when cutting a length of rope put on two whippings and cut between them.

k. Inspect rope frequently.

■ 19. UNCOILING AND COILING ROPE.—*a.* New rope is coiled into bales usually containing 1,200 feet each. To uncoil, begin with the end in the center of the coil. The rope should uncoil in a left-hand (counterclockwise) direction. If it uncoils in the wrong direction, turn the bale over, pull the end through the center, and uncoil from the opposite side.

31 19-20

(See fig. 43①.)

b. Coil rope in a right-hand (clockwise) direction (see fig. 43②). Mark the end of the rope that will enter the coil last, this is helpful in uncoiling

■ 20. DEFINITIONS.—*a. Knot.*—A knot is a tie or fastening made with a rope or cord. Types of knots include the following:

(1) *Bend knot* which fastens one rope to another or to a ring or loop

(2) *Hitch knot*, a temporary knot used to fasten one rope to another, or to spar or post, so as to be readily undone.

NOTE.—These terms are often loosely applied; the same tie for example, is called a sheet bend, weaver's knot, or weaver's hitch

(3) *Splice*, a knot joining two ropes, or parts of same rope, by interweaving strands of two parts.

(4) *Lashing*, a knot which ties together objects such as spars or poles by means of a rope. The individual ropes used in this knot are also called "lashings". rope of this kind, used to lash pontons, is about 18 or 20 feet long and ½ inch in diameter. It has an eye splice at one end and is whipped at the other end.

b. Special terms.—(1) *Anchorage.*—Any means, natural or improvised, for securing guys, ropes, struts, etc.

(2) *Bight.*—Loop formed on rope so that the two parts cross (or lay alongside) each other.

(3) *Chock.*—Bring blocks together until they touch each other

(4) *Frapping.*—Several turns of rope taken around lashing turns, used to keep the lashing tight and in place.

(5) *Guy.*—Rope, chain, or spar attached so as to steady an object.

(6) *Lay.*—The twist of a rope.

(7) *Mousing.*—Closing mouth of hook by lashing to prevent rope or load from becoming dislodged.

(8) *Overhaul.*—To separate the blocks in block-and-tackle rigging.

32 20-23

(9) *Reeve.*—Thread blocks with rope in assembling block and tackle.

(10) *Return.*—Each part of rope between blocks or between either end and a block.

(11) *Round (run) in.*—Bring blocks closer together.

(12) *Running end (part).*—Free end of rope.

(13) *Seizing.*—Lashing the running end to the standing part of rope.

(14) *Standing end (part).*—Whole rope less running end.

(15) *Tackle.*—Assembly of ropes and blocks.

(16) *Transom.*—Horizontal spar.

(17) *Unlay.*—Untwist rope.

(18) *Whipping.*—Binding or lashing end of rope to prevent unlaying.

■ 21. KNOTS AND THEIR USES.—For any one job a particular knot is the best to use; that is why there are so many knots an engineer must know. Learn to tie all the knots and learn to use them at the proper time. Figures 44 to 48, inclusive, illustrate the most common knots.

■ 22. SPLICES.—The three principal steps in splicing a rope are unlaying the strands, placing the ends together, and tucking the ends of the strands. No attempts should be made to learn to splice without having rope in the hands and actually executing the operations. Marlinespikes or ten pins are desirable, but no special tools are necessary.

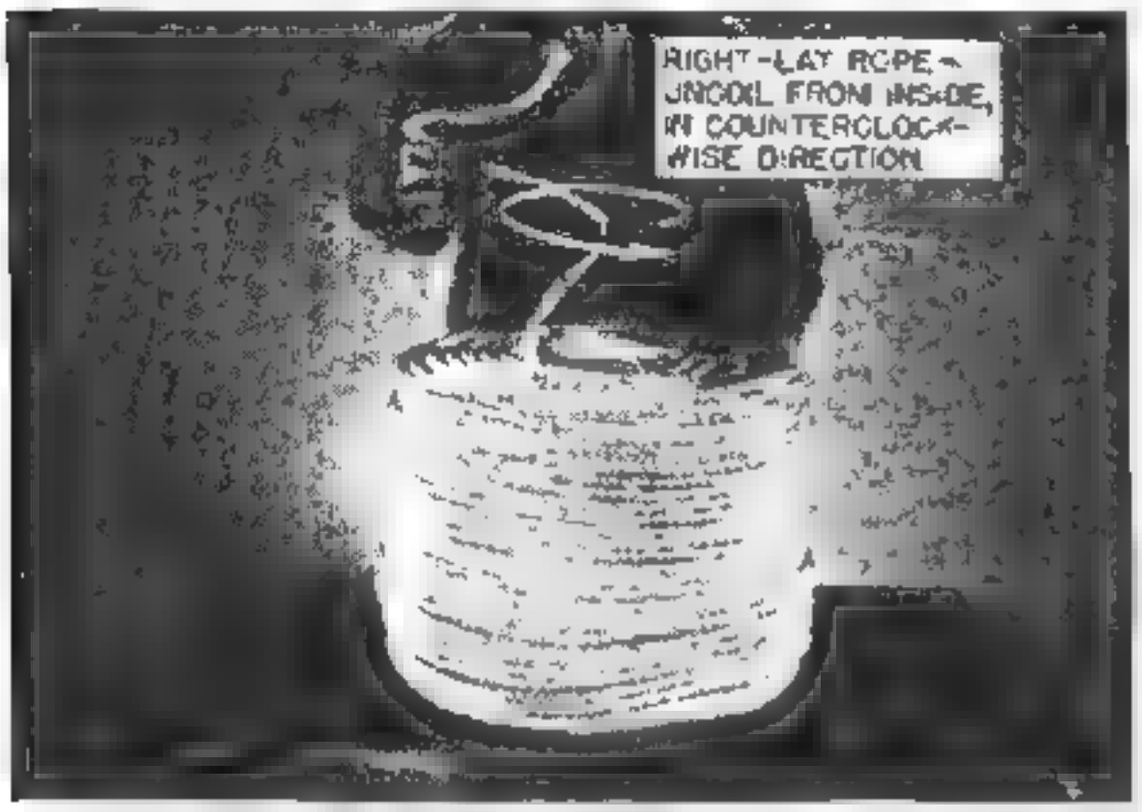
■ 23. SHORT SPLICE (fig. 49).—*a.* Short splicing is the best method to join two ropes when an appreciable increase of

rope diameter at the splice is not objectionable. A short splice should not be used when the rope will be passed over a pulley.

b. To make the short splice.—

(1) Unlay the strands of each rope for at least five turns.

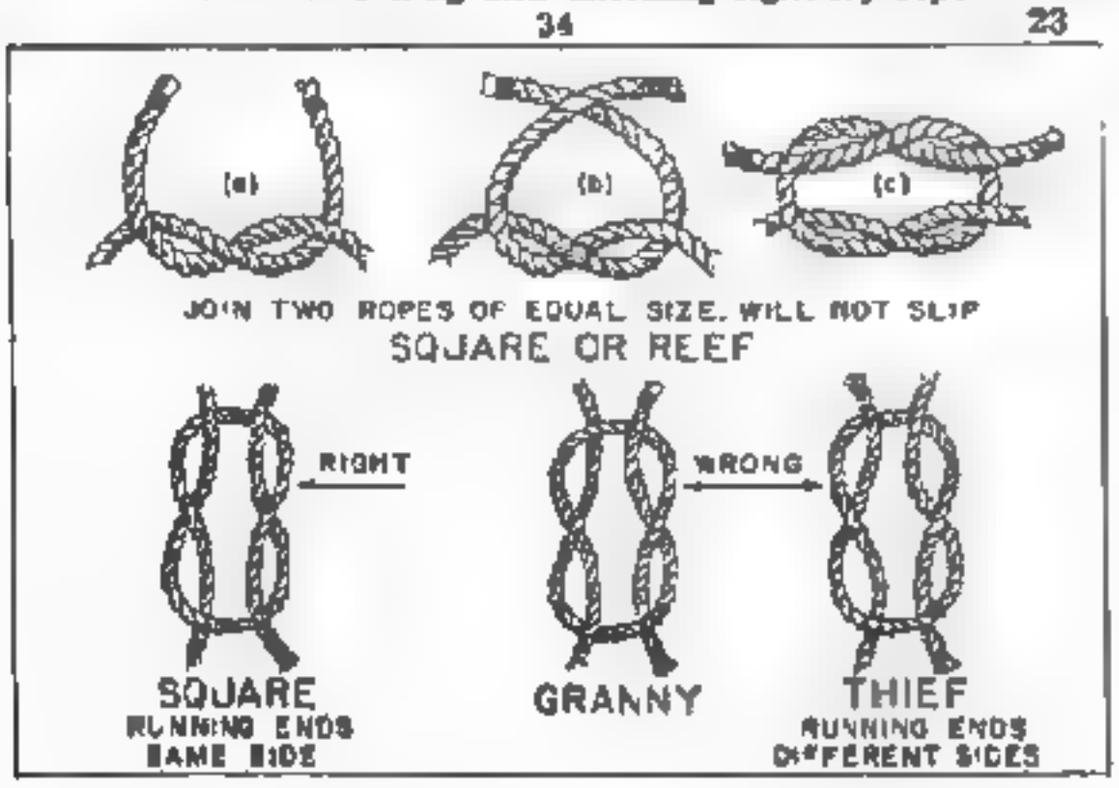
(2) Bring the ends of the rope together so that each strand of one rope rests between two consecutive turns of the other rope.



© Uncoiling

© Coiling.

FIGURE 43.—Coiling and uncoiling right-lay rope



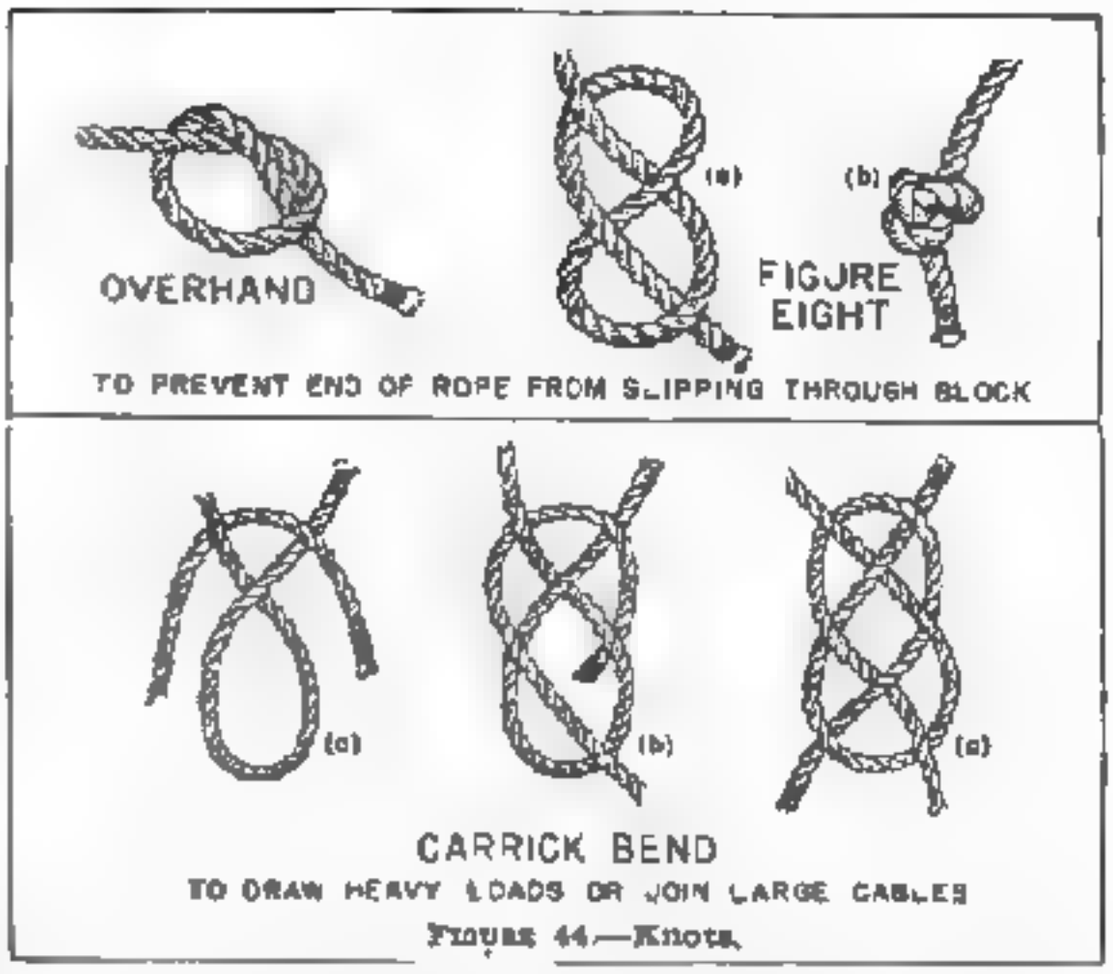


FIGURE 44.—Knots.

(3) To prevent unraveling as the splice is begun, tie a piece of twine around the dark rope at the beginning of the unraveling; tuck each of the dark strands by passing over one strand and under the next of the white rope.

(4) Remove the twine and tuck the free strands of the white rope over and under the strands of the dark rope in

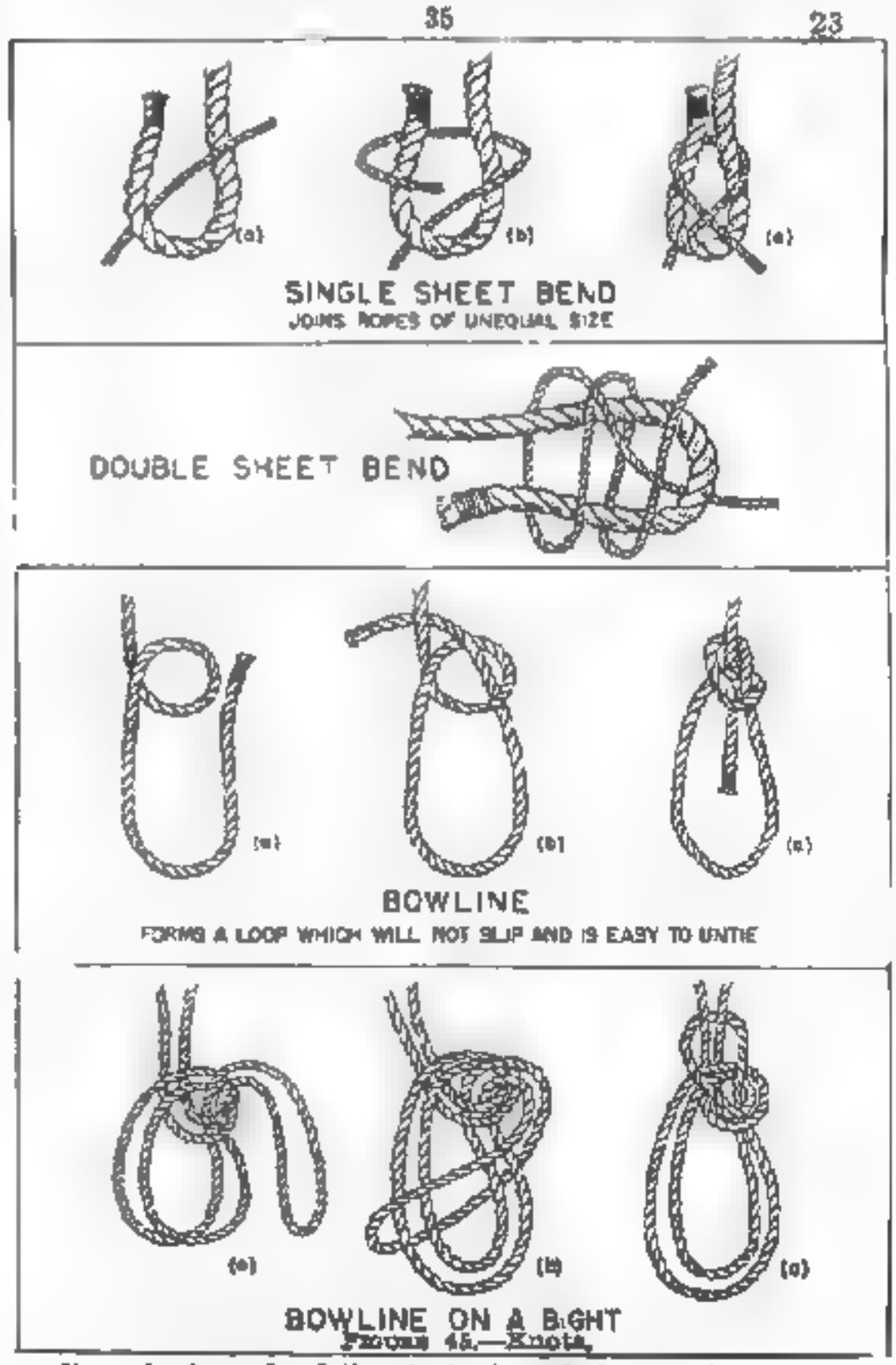


FIGURE 45.—Knots.

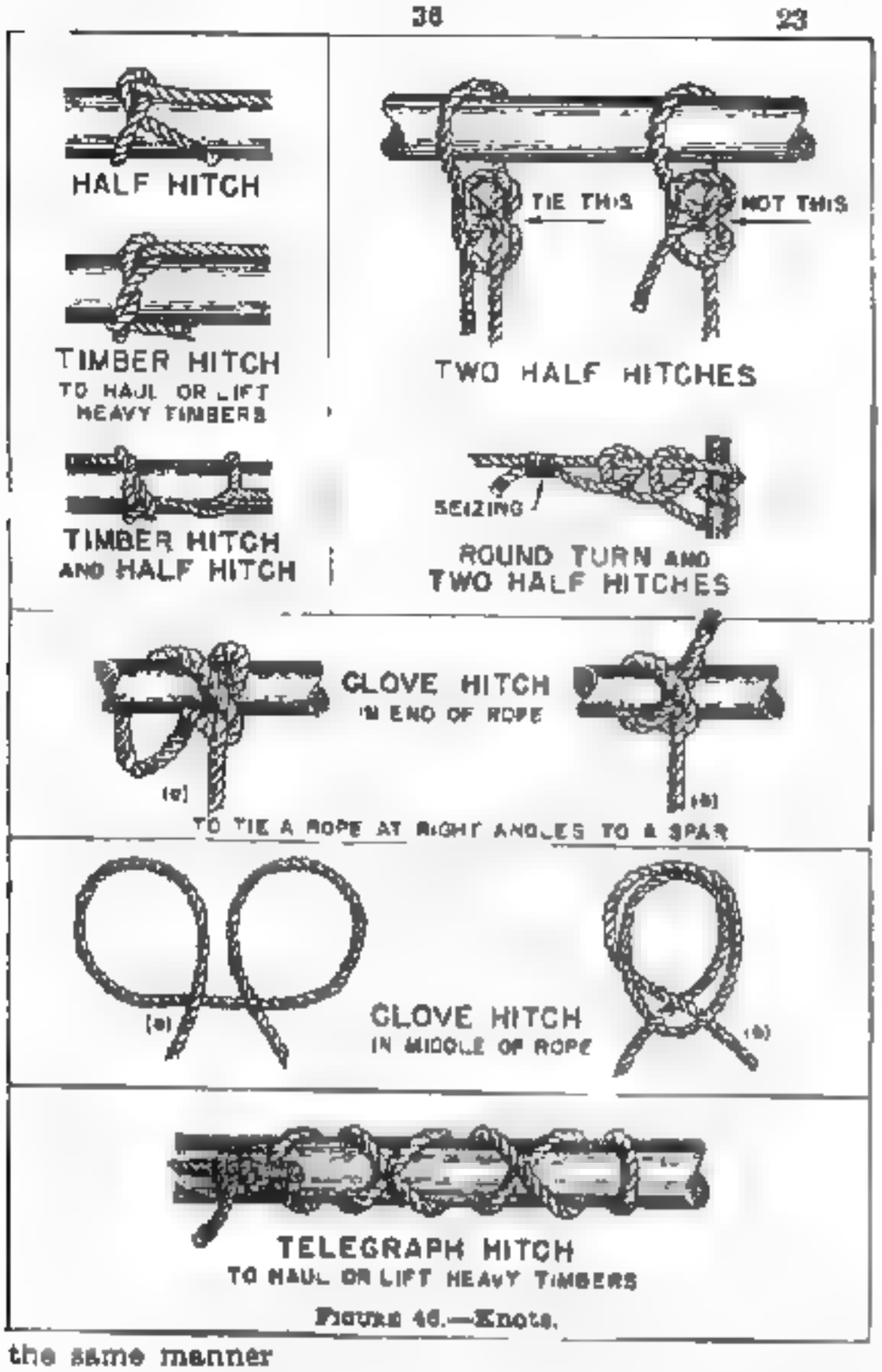
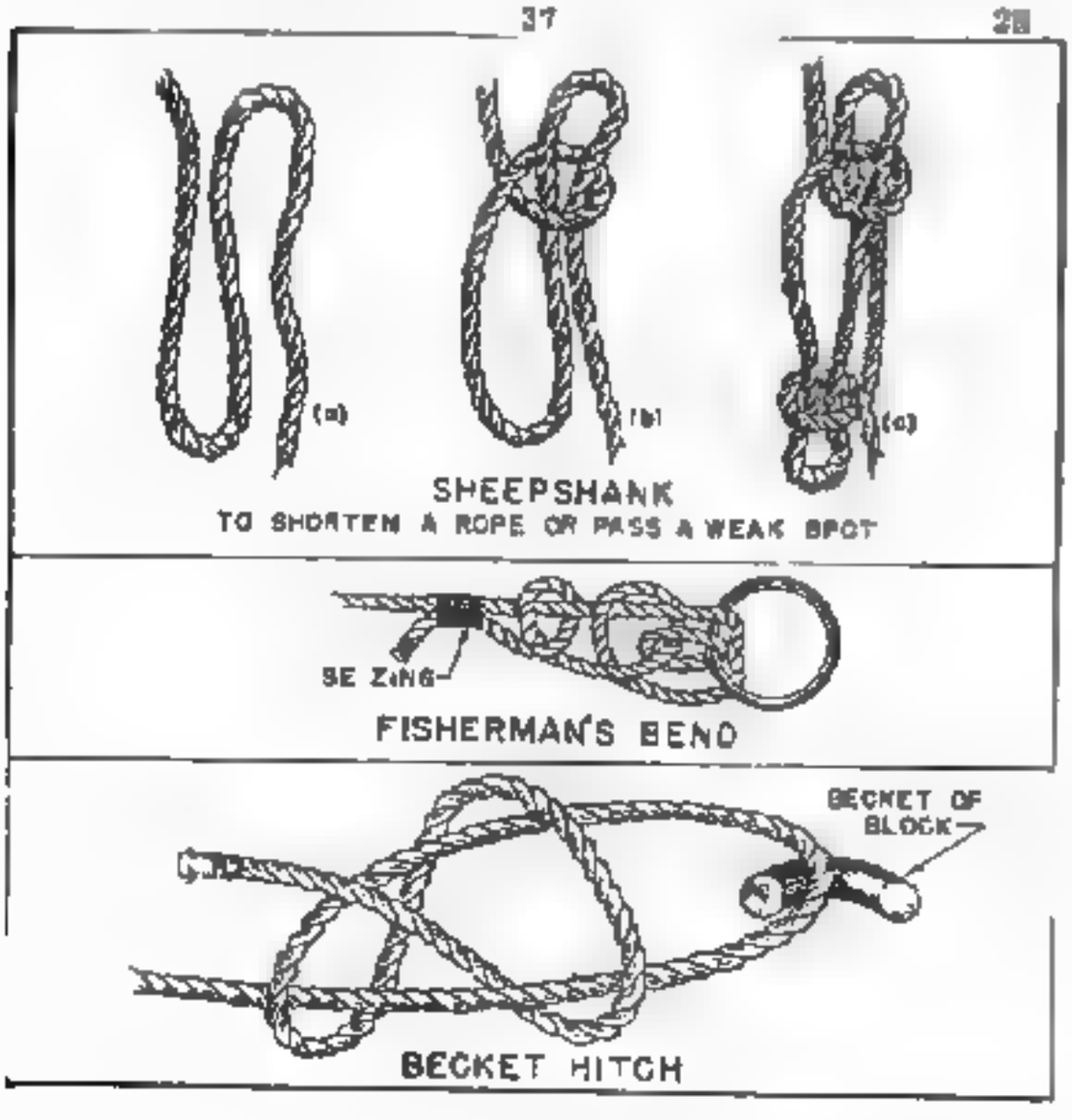


Figure 46.—Knots.

the same manner

(5) Make at least three more tucks with the first rope, repeat for the white rope, and cut off the loose ends. The



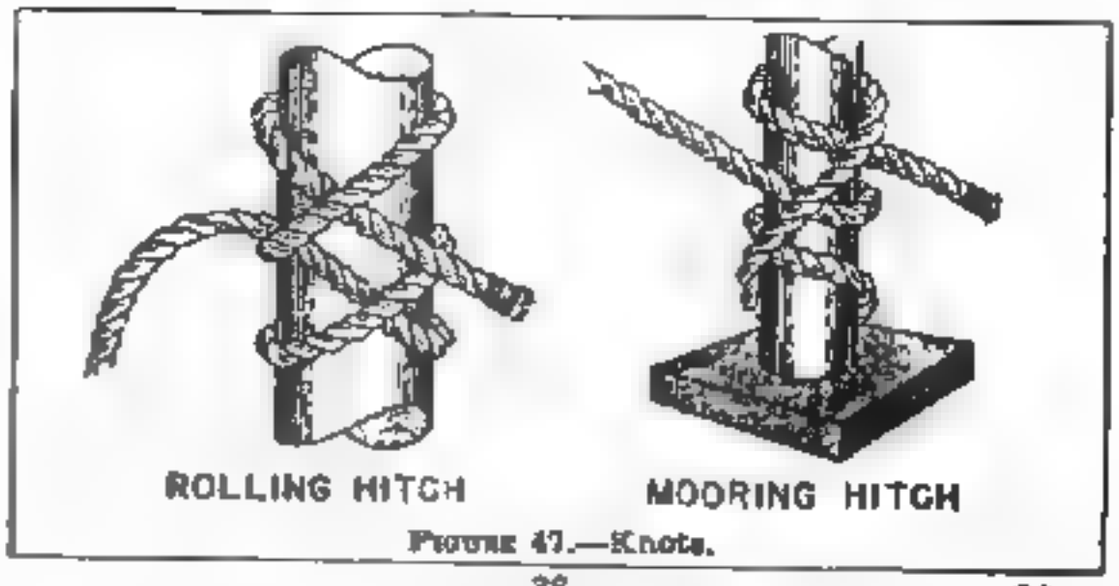


Figure 47.—Knots.

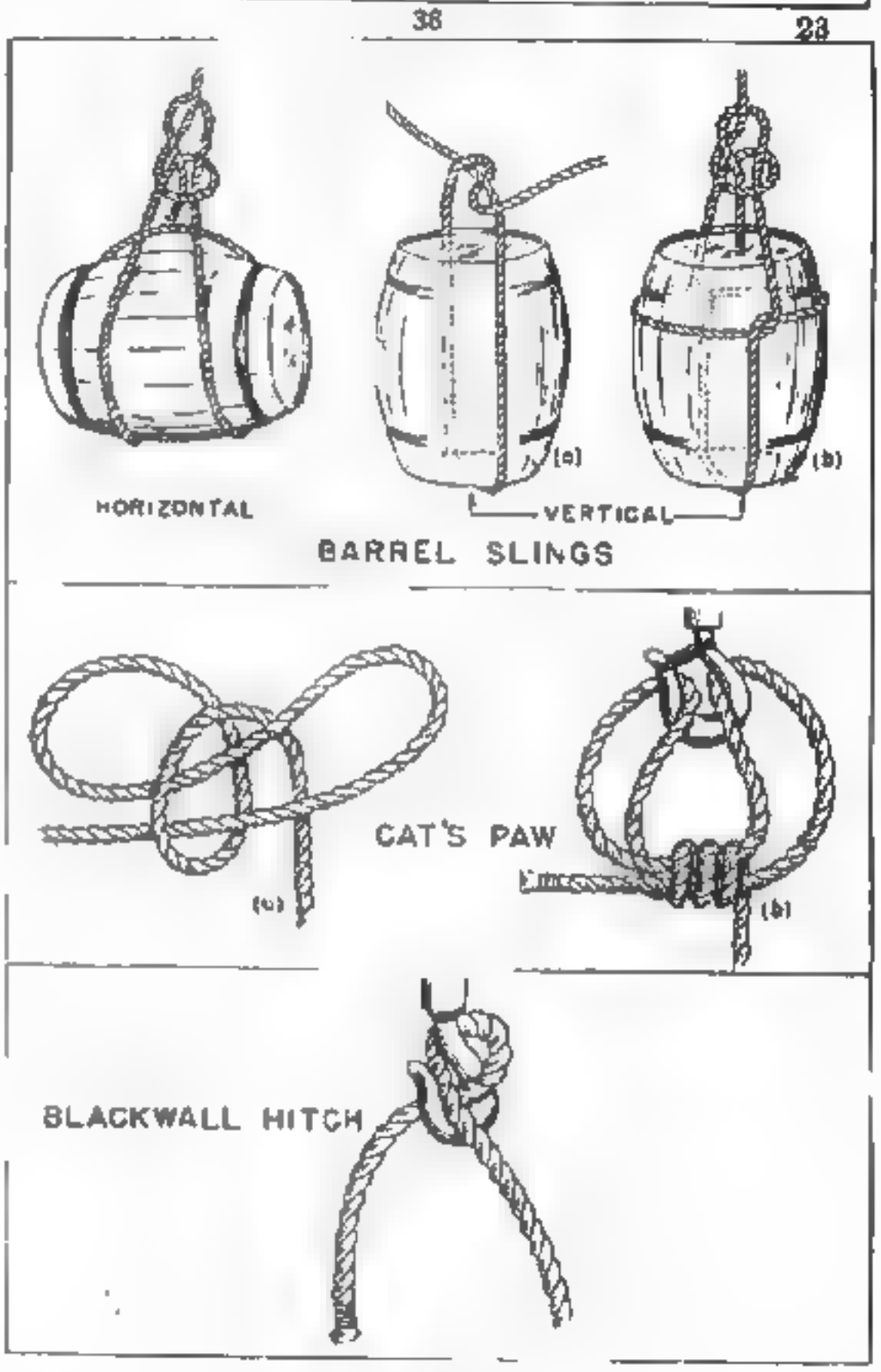


Figure 48.—Knots.

39 23–24

ends of the splice may be tapered by continuing the tucking process for two or three tucks, cutting out a few fibers from each strand after each tuck. Rolling the splice (under the foot or under a board) will make it compact and smooth.

■ 24. Long Splice.—The long splice must be used where it is necessary to keep the increase in diameter to a minimum. It also has a neater appearance. The long splice is used to join ropes of equal size when the rope is to run through a block.

a. Stage 1: Unlaying.—To make a long splice in a three-strand rope (see fig. 50)—

(1) Unlay 15 turns from the ends and tie strings about one

of the ropes at these points.

(2) Bring the two parts together in the same manner as for the short splice.

(3) Beginning at the point where the two parts are placed together, unlay one of the strands to the right, and lay carefully in its place all but the last five turns of the corresponding strand from the left. This latter operation should follow closely the unlaying of the strand to the right. There are still two pairs of strands left at point *A* where the ends were placed together.

(4) Remove the piece of string and run one of these pairs to the left in the same manner as the first pair to the right; cut off the long ends of the strands (including the two remaining at *A*) about five turns from the main rope

b. Stage 2: Tucking.—The next part of the splicing consists in tucking the ends of the three pairs of strands. All are tucked in the same manner, as follows: being sure that the ends of the strands pass each other as illustrated in (a) (fig. 50) and not as in (b). As shown in (c), bring the strand from the right up over the nearest strand from the

40 28

FIGURE 49.—Short splice.

41 24–27

left and under the next strand (d), and (e) give the strand from the left one tuck (f). (g) Each strand should now be given two more tucks in a direction almost at right angles to the direction of twist. When all three pairs of strands have been tucked, cut off the ends and make smooth by rolling.

■ 25. EYE SPLICE.—The eye splice is used to secure a rope permanently to a ring or becket and for making a permanent loop in the end of a rope. To make an eye splice (see fig. 51)—

a. Unlay about five turns on the end of the rope and pass the middle free strand (b) under a strand of the rope so as to form a loop of the desired size.

b. Pass a second free strand (a) under the next strand of the rope.

c. Pass the third free strand (c) under the third strand of the rope as shown in "inset A"; tuck the free strands into the rope (over one strand and under the next) in the same manner as the short splice.

d. Draw all the strands taut and cut off the loose ends.

■ 26. RENEWING A BROKEN STRAND.—Unlay each broken end for about 10 turns; secure a strand of the same size rope about 20 turns in length and lay all but about 5 turns at each end of it into the broken rope in place of the broken strand; join the new strand at each end with an overhand knot with the end of the broken strand; cut the ends of the broken strand to 5 turns and tuck the ends as in the long splice.

■ 27. CARE AND USE OF WIRE ROPE.—Correct handling of wire rope at all times is essential to maximum service. The following precautions should be observed:

a. Reels of wire rope should not be dropped. Weight of rope may break reel, permitting rope to become kinked.

b. Prying with bars should be done on flanges of reel, not on rope.

c. Wire rope should be stored in a dry place and away from corrosive fumes. Outside layer of reel or coil should

42 27

FIGURE 50.—Long splice.

be protected by a coating of lubricant. Wire in use should be well lubricated.

d. Newly installed wire rope should be worked for a while without load to enable rope to adjust itself to working conditions.

e. To avoid sharp kinks, all loops in slack rope should be straightened before load is applied. To remove a kink, wire

43 27

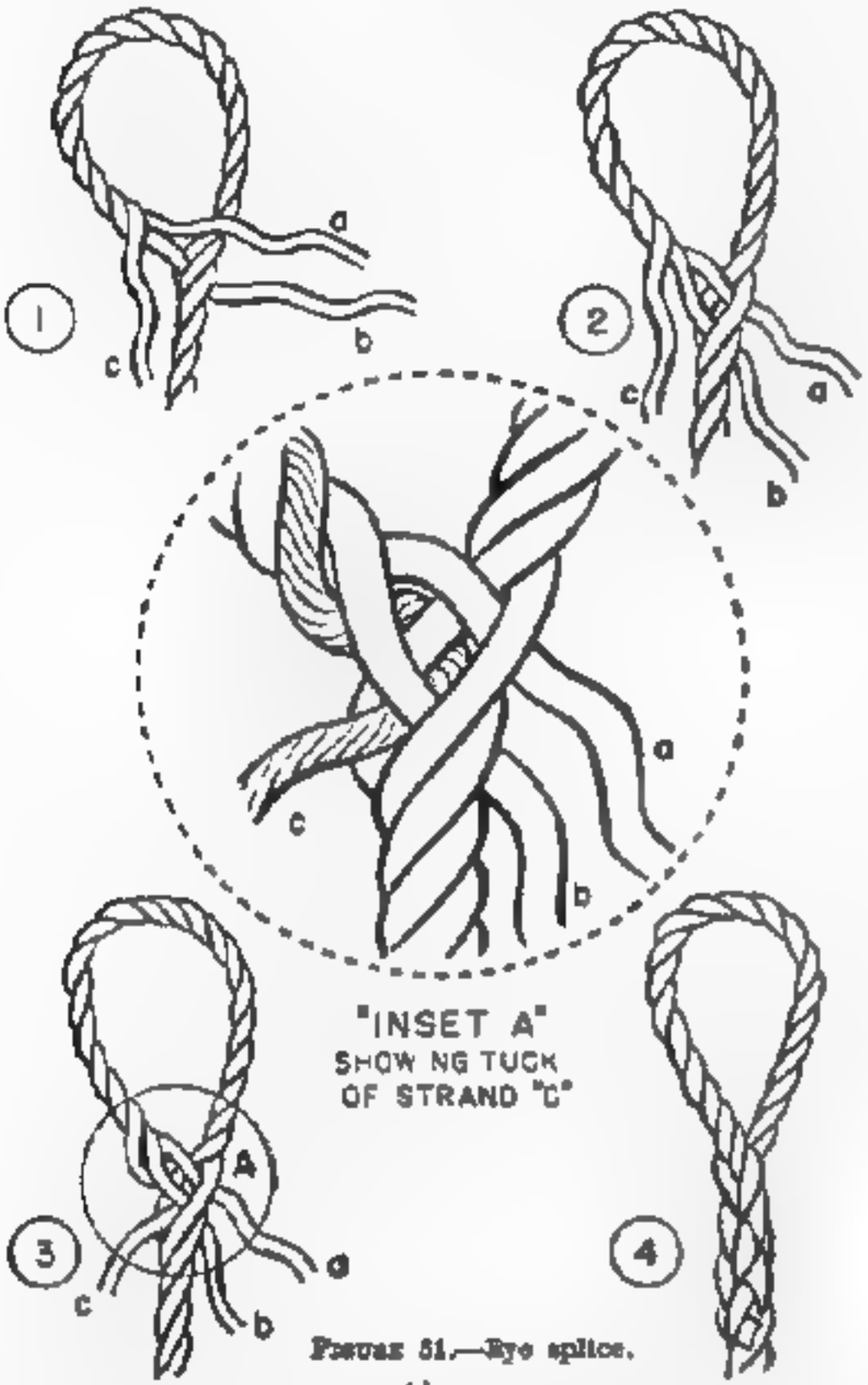


FIGURE 51.—Eye splice.

44 27

rope must be bent back and reversed to direction in which kink was formed. A kink cannot be straightened by pulling the rope taut; this merely unlays the rope.

f. Loads must not be applied suddenly. This puts excessive strain on rope.

g. Avoid using wire rope on sheaves or drums which are too small, and avoid reverse bends or sudden changes in direction of pull. Either of these conditions causes severe strain and broken wires in strands and weakens rope.

h. It is best to wind only a single layer of rope on drums; however, if necessary to wind more layers, second layer is wound on grooves formed by first, except that once in each turn rope crosses over two sections of first layer. Third layer is parallel to first layer and wound on grooves of second, except at crossovers. In all cases when it is expected to wind a second layer, the turns of first layer must be wound together tightly to prevent possible binding.

i. Ropes should not be pulled around small trees or flat surfaces. This causes strands to spread.

j. Distance between hoisting drum and first sheave should be not less than 15 feet per foot of drum width. Distances shorter than this cause excessive rope abrasion.

k. When removing wire rope from reel or coil, reel or coil must rotate as the rope unwinds. Attempts to unwind rope from stationary coils will result in kinking.

(1) A correct method for unreeling wire rope is to mount reel on a shaft supported at each end. Rope is then pulled off, permitting reel to rotate. When spooling wire rope from reel to drum, rope should travel from top of reel to top of drum, or from bottom of reel to bottom of drum. This prevents reverse bends which make rope difficult to handle.

(2) To uncoil wire rope, end is held stationary while coil is rolled out on ground. This method prevents kinks.

l. When coiling wire rope loose as it comes from drum, determine lay of rope; if left lay, coil to left (counterclockwise), or if right lay, coil to right (clockwise). When finished, ends of rope should be tied to coil, and top or end should be marked to aid in uncoiling.

m. To wind wire rope on reel or drum, the following rule is convenient to determine proper starting flange; the left

45 27-28

hand is used for left-lay rope, and the right hand for right-lay rope; back of the hand is up for overwinding and down for unwinding. Standing behind and facing drum, the fist represents the drum, and the extended index finger, the rope leading away from drum; thumb indicates at which flange rope should start. Thus, for a left-lay rope overwinding, back of left hand is up, index finger points along rope leading away from drum, and thumb to right indicates that rope should be started on right-hand flange.

n. To avoid accidents, every reasonable effort should be made to stand clear of any wire rope under tension

o. When rope used on drums and sheaves has had approximately half of its normal use, ends should be reversed to change points of wear.

■ 28. LASHINGS AND SPARS.—*a. Square lashing (two spars at right angles)* (see fig. 52).—To lash two spars at right angles make a clove hitch around the upright a few inches above the transom. Bring the lashing under the transom, up in front of it, horizontally behind the upright, down in front of the transom, and back behind the upright at the level of the bottom of transom and above the clove hitch. Keep the following turns outside the previous ones on one spar and inside on the other, not riding over the turns already made. Make four more turns. Make two frapping turns between the spars, around the lashing, and finish the lashing off either around one of the spars or any part of the lashing through which the rope can be passed. Do not make the final clove hitch around the spar on the side toward which the stress is to come, as it may jam and be difficult to remove. While tightening, beat the lashing with a handspike or pick handle.

b. Three spars for tripod (see fig. 52).—(1) To lash three spars together as for a gin or tripod, mark on each spar the location of the center of the lashing. Lay two of the spars parallel to each other with an interval a little greater than the diameter. Rest their tips on a skid and lay the third spar between them with its butt in the opposite direction, so that the marks on the three spars will be in line. Make a clove hitch on one of the outer spars about 4 inches above

46 28

the lashing mark, and take eight or nine loose turns around the three spars. Take a couple of frapping turns between each pair of spars in succession and finish with a clove hitch on the central spar above the lashing. Pass a sling over the lashing and the tripod is ready for raising.

(2) Figure 52 also illustrates an alternate method for lashing three poles together for a tripod

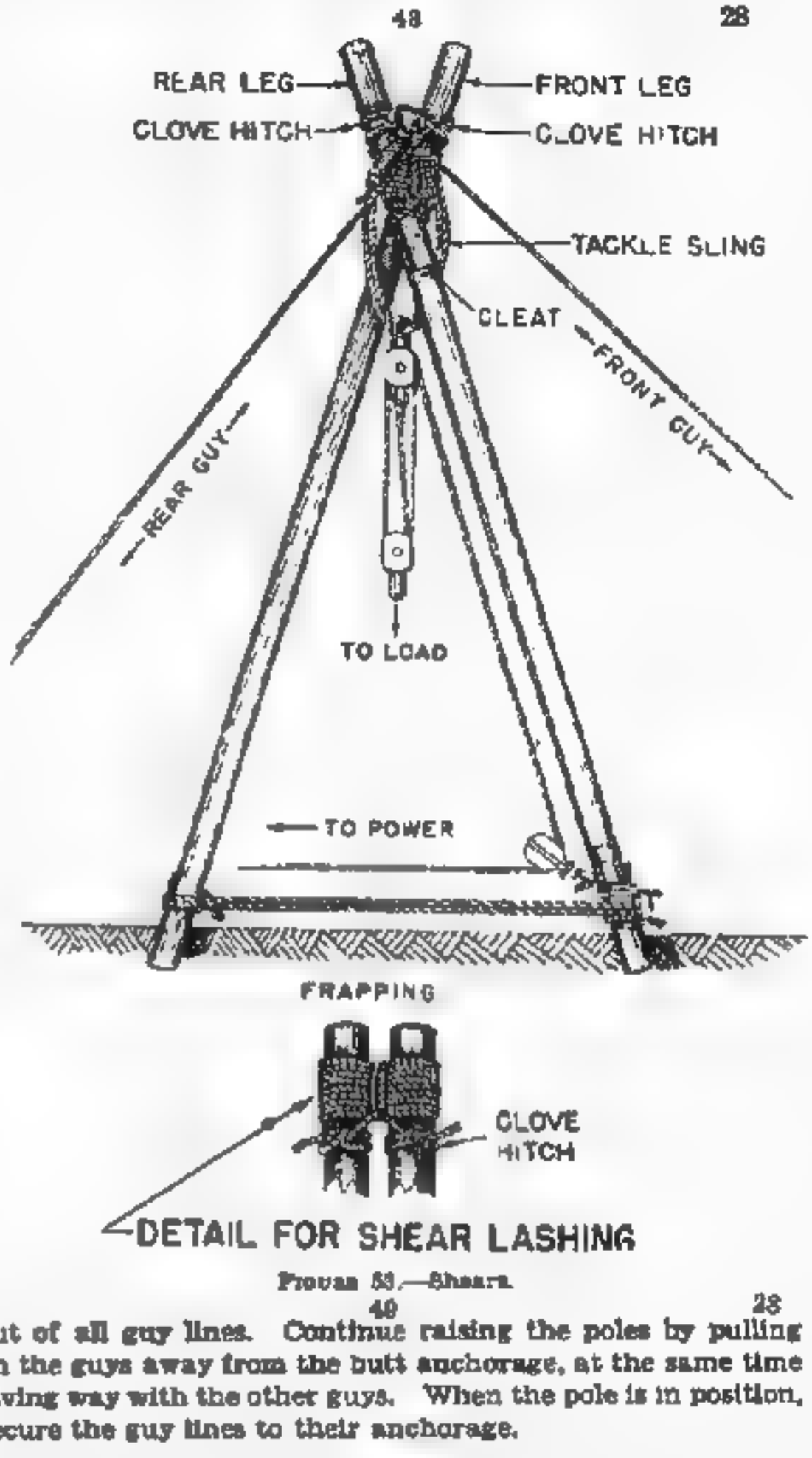
c. Pair of shears (fig. 53).—To lash for a pair of shears, lay the two spars alongside each other with the butt ends

near the place where they are to be erected; rest the points below which the lashing is to be made on a skid. Make a clove hitch around one spar and take the lashing loosely eight or nine turns about the two spars, above the clove hitch, without riding Make two or more frapping turns between the spars, and finish the lashing off with a clove hitch below the turns on the other spar. Open the butts of the spars and pass a sling over the fork. Hook or lash a block to this sling. Make fast fore and back guys with clove hitches to each spar just above the fork, so that the rear guy pulls on the front leg and the front guy, the rear leg

d. Gin pole.—A gin pole is used to handle heavy loads. The pole should be no longer than 60 times its smallest diameter; otherwise the pole may buckle under a load.

(1) *Rigging a gin pole* (fig. 54).—Lay the pole on the ground with the base (large end) at the spot where the pole is to be erected. Make a tight lashing of eight or nine turns about 1 foot from the top of the pole; with two or more of the central turns engage the hook of the upper hoisting block. Nail cleats to the pole to prevent the lashing from sliding down the pole. Attach the guy lines with a clove hitch just above the tackle lashing, and nail cleats to the pole just above the guy lines to prevent their slipping off. Lash a block to the butt of the pole about 2 feet above the base in the same manner as at the top of the pole. Now reeve the hoisting tackle.

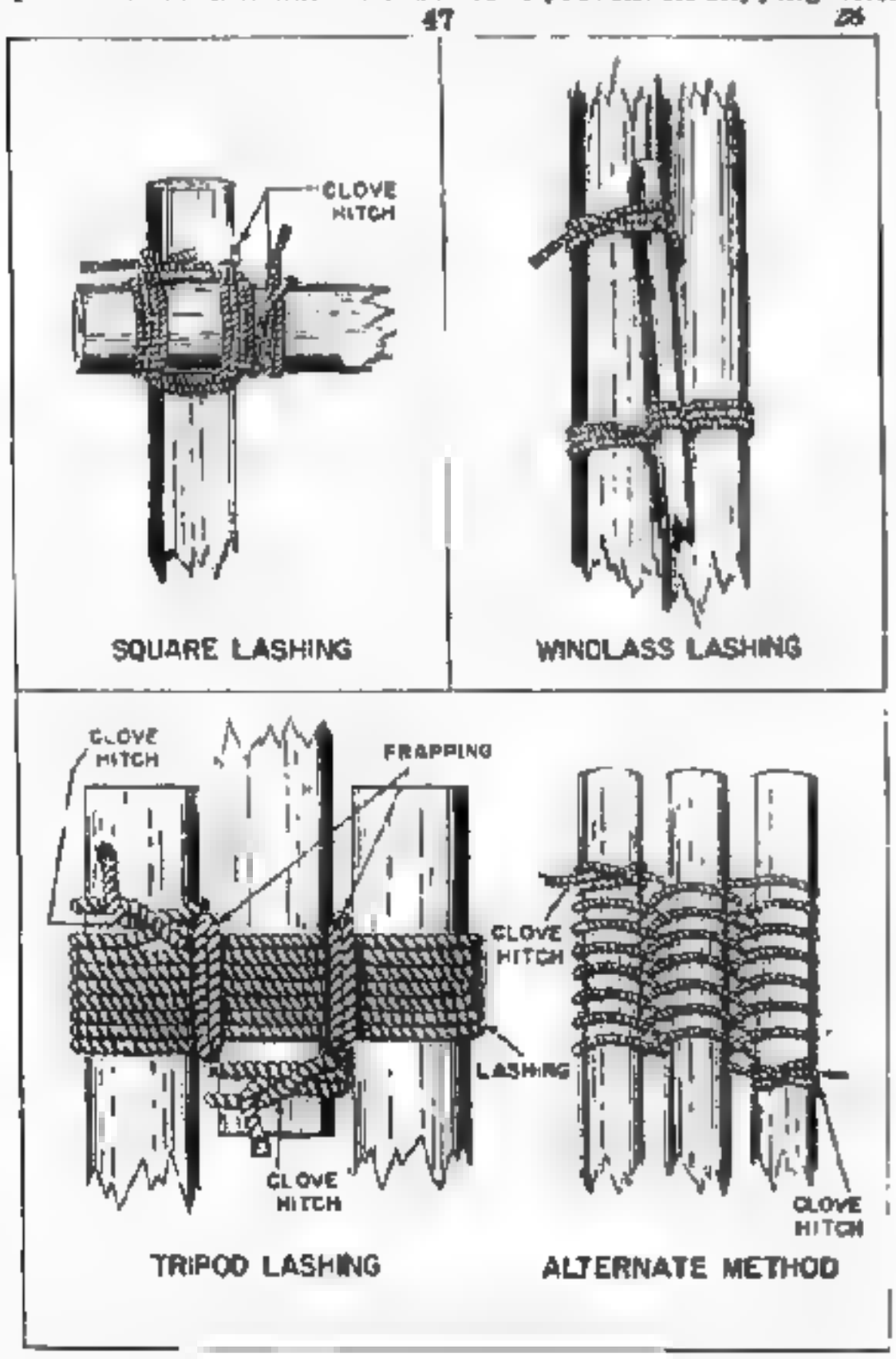
(2) *Erection* (fig. 54).—Dig a hole where the base of the pole is to rest and anchor the base to prevent its slipping when the pole is raised. String out the guy lines to their respective anchorages and the pole is ready to be raised. Raise the top end of the pole a few feet off the ground and take the slack



DETAIL FOR SHEAR LASHING

FIGURE 53.—Shears.

out of all guy lines. Continue raising the poles by pulling on the guys away from the butt anchorage, at the same time giving way with the other guys. When the pole is in position, secure the guy lines to their anchorage.



FIGURES 52.—Details of lashings and spars.

■ **29. ANCHORAGES.**—*a. Holdfasts* (see fig. 55).—(1) *Use.*—Holdfasts are used to anchor a line to the ground, as for a

(2) *Directions for making.*—To make a holdfast, drive stout pickets into the ground, one behind the other, in the line of pull. Secure the head of each picket, except the last, by a lashing to the one behind it. Tighten the lashings by rack sticks and then drive the points of these into the ground to hold them in position. The distance between pickets should be several times the height of the picket above the ground.

b. Deadman (see fig. 55).—(1) *Use.*—A deadman has the same use as a holdfast except that it has greater strength, although it requires more labor to construct

(2) *Directions for preparing.*—To prepare a deadman, lay a log or timber in a transverse trench with an inclined trench intersecting it at its midpoint. Pass the cable down the inclined trench, take several turns around the log, and fasten the cable to the log by half hitches and marline stopping.

If the cable is to lead horizontally or incline downward, pass it over a log at the outlet to the inclined trench. If the cable is to lead upward, the log is not necessary, but the deadman must be buried deeper. Stakes driven at an angle over the log prevent it from rolling out.

■ 30. BLOCKS AND TACKLES (figs. 56 and 57).—The parts of a block are the shell or frame, the sheave or wheel upon which the rope runs, and the pin upon which the wheel turns in the shell. Blocks are designated by the length of the shell in inches and by the number of the sheaves. Those with one, two, three, or four sheaves are called single, double, triple, and quadruple. The smallest size of block (length in inches) that will take a given rope is nine times the rope diameter. Self-lubricating blocks should be used where obtainable.

a. Definitions.—(1) *Snatch block.*—A snatch block is a single block with the shell open at one side to admit a rope without passing the end through.

(2) *Running block.*—A running block is attached to the object to be moved. In compound tackle, however, a running block may be suspended by ropes.

(3) *Standing block.*—A standing block is fixed to some permanent object.

(4) *Simple tackle.*—A simple tackle consists of one or more blocks rove with a single rope.

b. Uses.—Blocks are used to change the direction of pull and to give mechanical advantage. A man of average weight will pull about 60 pounds horizontally.

c. Mechanical advantage.—The mechanical advantage of the block and tackle is found by dividing units of weight lifted by units of pull (force) necessary to lift it. In simple tackles the mechanical advantage gained is a direct function of the number of ropes *supporting* the load. Thus, if the movable block is a double one, four or five ropes will sustain the load (depending on the direction of pull) and the mechanical advantage gained is four or five in theory. Actually, because of friction, the real advantage is always somewhat less. Figures 57 and 58 illustrate the use of block and tackle and show the mechanical advantage obtained.

d. Strength of rope.—An ordinary manila rope will safely carry a load in tons equal to its diameter (in inches) squared. For example, a rope ⅜ inch in diameter will carry ¾ by ¾ or 9/16 tons=9/16 by 2,000 or a 1,125-pound load.

■ 31. SAFETY PRECAUTIONS.—Observe the following rules when working with heavy loads:

a. Do not stand or walk under heavy loads that are suspended from cribs, jacks, or slings.

b. Use knots and lashings only for the purpose intended. For example, do not use two half hitches to hoist a spar, but use a timber hitch.

c. It is dangerous to drop heavy weights, even for short distances. Often they must be moved slowly, with chocks to stop them if they break away.

d. When raising heavy loads with tackle, it is often necessary to follow it up by cribbing; then, if tackle fails, load will be caught on crib.

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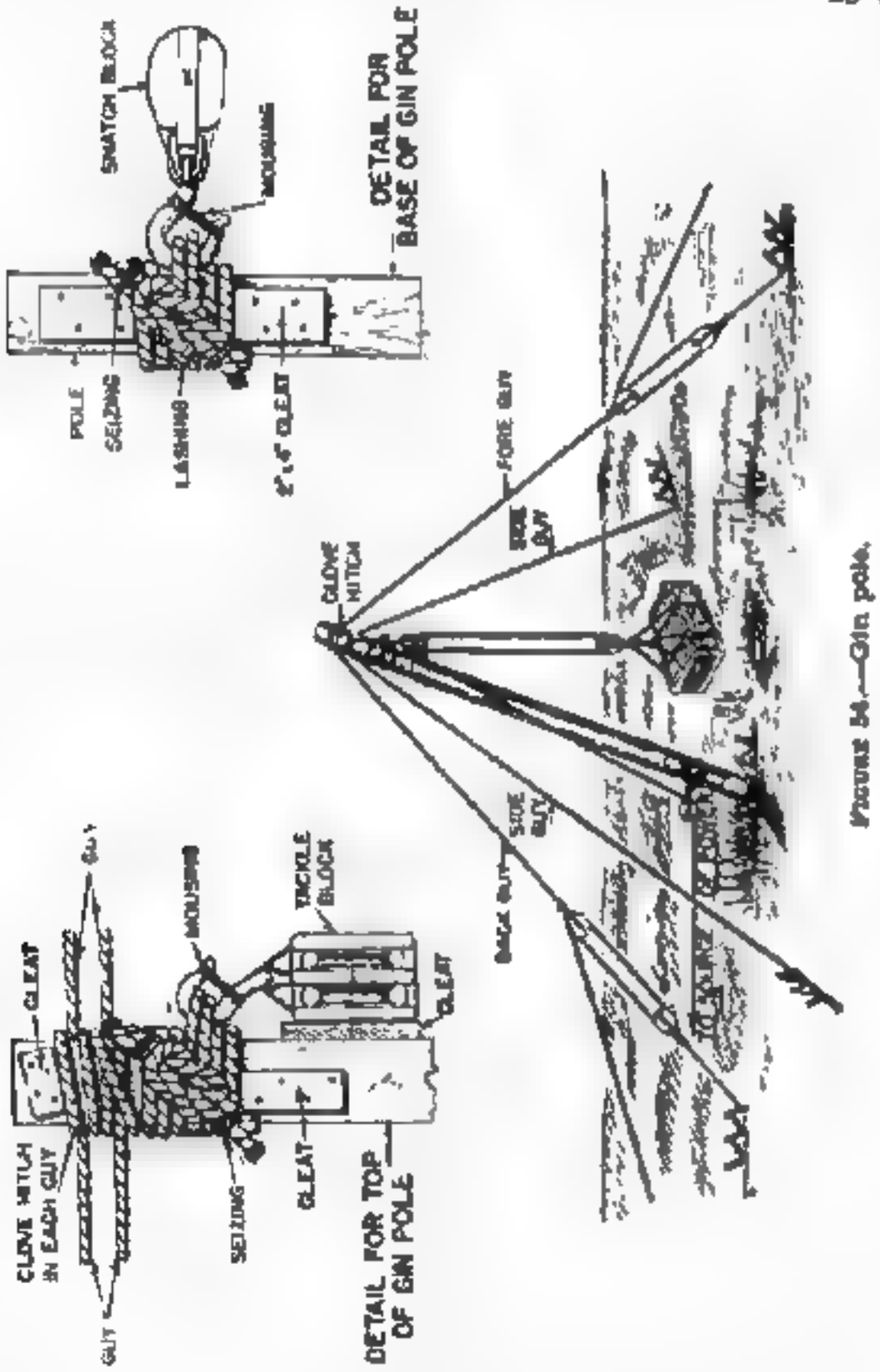

FIGURE 56.—Gin pole.

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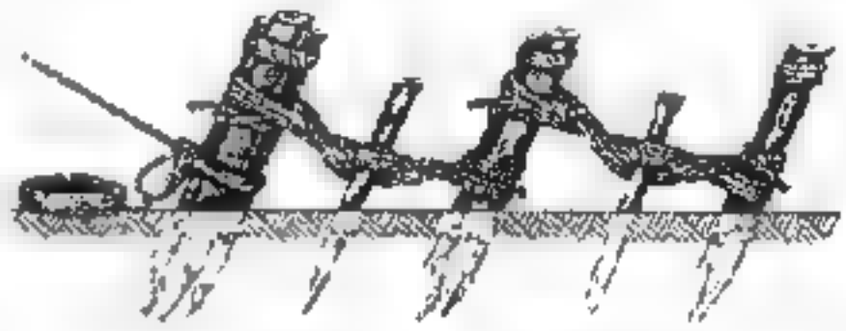

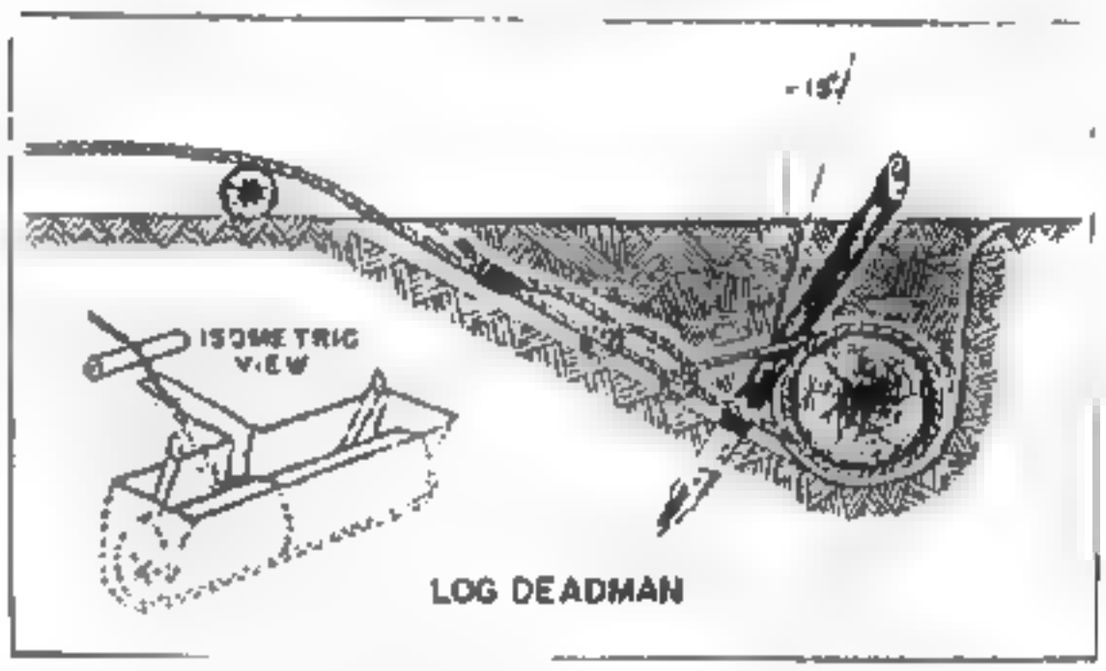

FIGURES 53.—Picket holdfasts and deadman.

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53 31

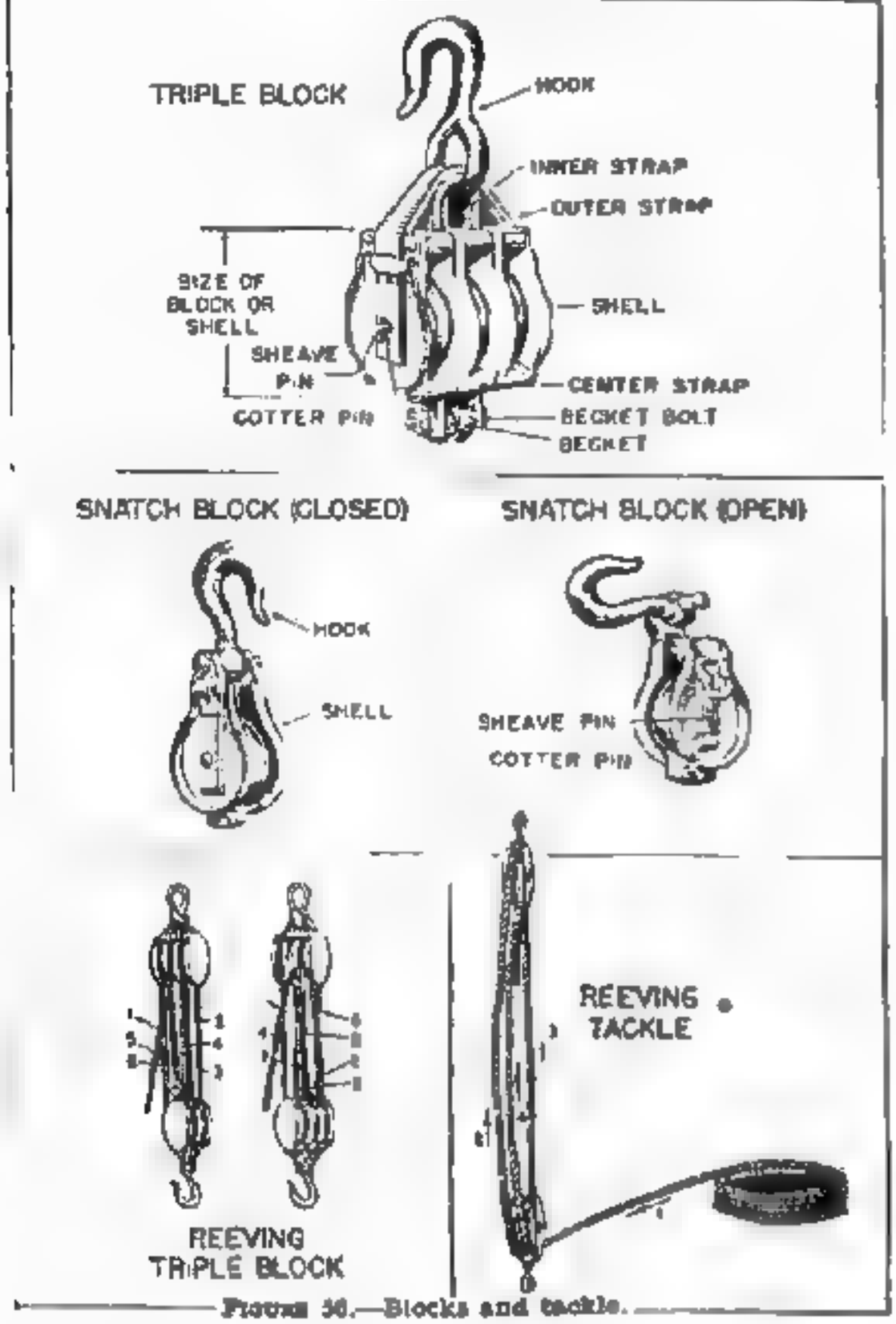

FIGURE 56.—Blocks and tackle.

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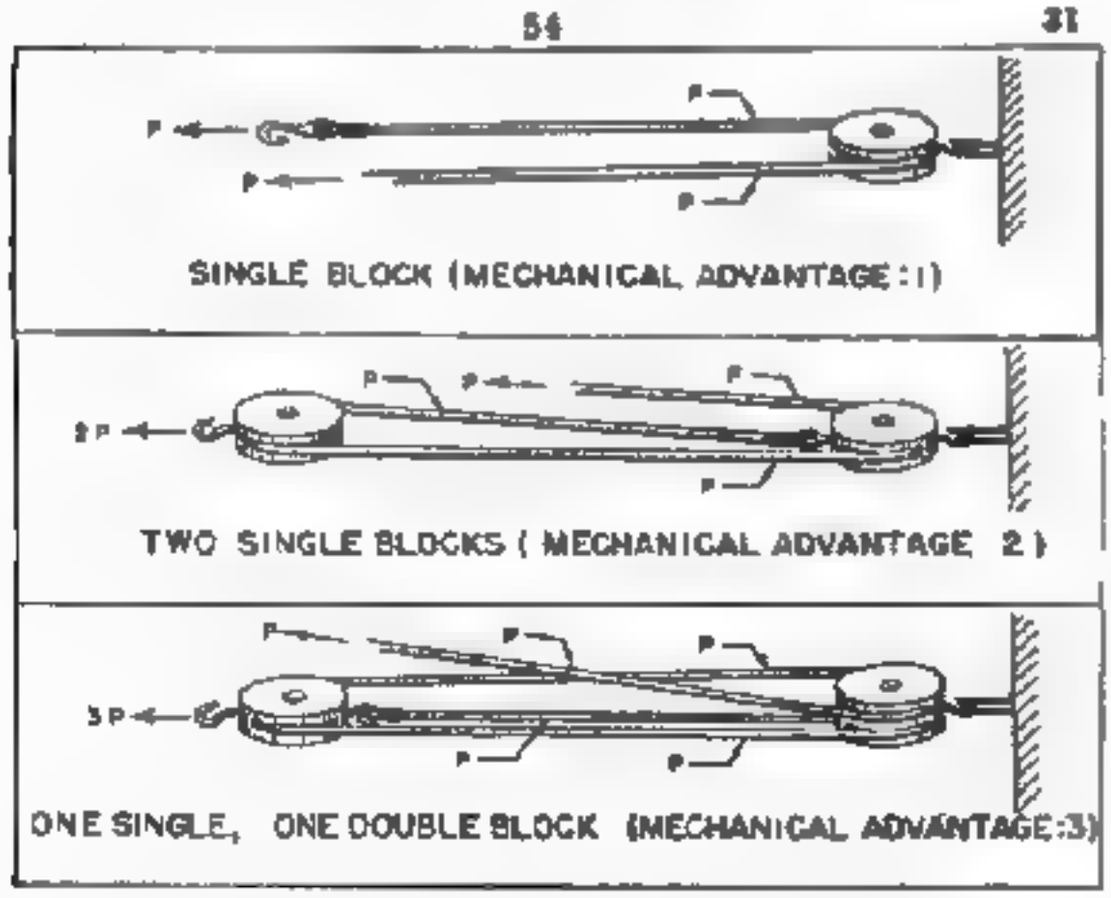

FIGURE 57.—Simple tackles. Examples of block and tackle rigging, showing mechanical advantage. Each p represents a rope which supports an equal part of the weight acting on the whole tackle.

e. Use equipment that is in good condition and of proper size. Do not use old frayed rope or rotted timbers.

f. See that all supports and holdfasts have a firm base and that cribbing has level foundation and is built up vertically.

g. Do not put your foot in bight of a running rope or step on or across a taut rope.

h. Do not hang or lean on guy lines.

i. When two or more men are lifting or hauling together, the preparatory command is LAY HOLD, and strength is exerted at command **HEAVE.** When movement is sufficient, man in charge will command **EASE AWAY.** At this command, slack off slowly to insure that load is secure before releasing its support.

j. Whenever possible, have lines snubbed around trees or holdfasts, so that in case of trouble load can be safely held in position.

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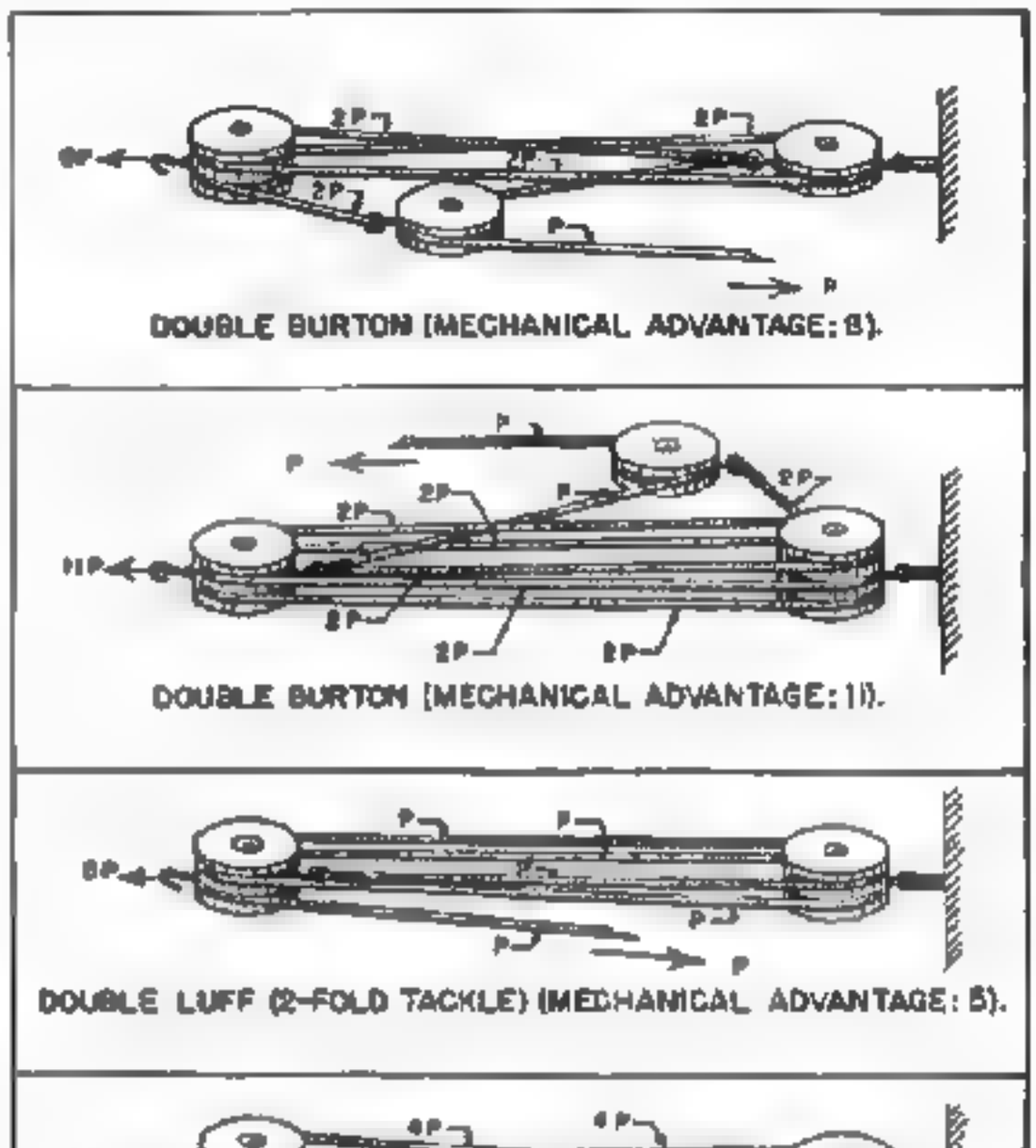


FIGURE 58.—Compound tackles. Examples of block and tackle rigging, showing mechanical advantage. Each p represents a rope which supports an equal part of the weight acting on the whole tackle.

56 82–34

CHAPTER 4

FIELD FORTIFICATIONS

■ 32. HIT THE GROUND AND DIG IN.—*a.* When you are exposed to enemy fire the best way to obtain individual protection is to dig a protective hole from which you can fire. Depending upon how much time you have and upon other conditions, such as enemy fire, available tools, and type of earth, there are a number of standard entrenchments which will protect you best. Terrain is evaluated for military use according to the following factors:

(1) Observation.

(2) Field of fire (firing position).

(3) Cover (including protection from small-arms fire, shell and bomb fragments, and the crushing action of tanks) and

concealment.

(4) Obstacles.

(5) Covered approaches.

b. All grades of soldiers must learn automatic *choice of position* with the above factors in mind. Some entrenchments offer better protection than others. Dig the one you have time for and improve it every chance you get. The *important thing is to start digging as soon as you can.*

■ 33. ENTRENCHING TOOLS.—Infantry troops carry in their packs small individual digging tools with which they dig entrenchments. Engineers carry no such tools, but in engineer transportation and pioneer tool sets there are standardsize picks, shovels, and axes. When these are unavailable you must use whatever is at hand, such as meat-can cover, canteen cup, bayonet, sticks, or anything else with which you can dig a hole.

■ 34. PRONE SHELTER (fig. 59).—When you are halted for more than a few minutes and are out of contact with the enemy, the prone shelter should be built. It is comparatively easy to construct and it protects you from bomb fragments. You can lie down in it and rest. *But it does not protect you against the crushing action of tanks.*

■ 35. SHELL-HOLE POSITIONS (fig. 60).—In a shell-pitted area, improved shell holes offer quick protection and some concealment with only a small amount of labor.

■ 36. FOX HOLES (figs. 61 and 62).—Fox holes afford maximum cover from any kind of fire, and also give protection from tanks.

■ 37. WEAPON EMPLACEMENTS.—Engineers not only build their own entrenchments and emplacements, but they also may be called upon to build such positions for other troops. Therefore you should be familiar with the design of emplacements for infantry weapons as well as your own weapons. Figures 63 to 66, inclusive, show machine-gun emplacements. Figure 67 is an emplacement for the 37-mm antitank gun. In order to illustrate clearly the design of these emplacements, concealment and camouflage have been purposely omitted. Remember that alternate positions are habitually dug for each weapon, as a weapon that is fired from one place cannot survive for long.

■ 38. REVETMENT.—The walls of entrenchments sometimes need support. The process of bolstering these walls is called reveting. Revetments may be made with sandbags (fig. 42) or with pieces of wood (fig. 68).

■ 39. BARBED WIRE.—*a.* Barbed wire is a difficult obstacle for men, animals, and wheeled vehicles. It is often necessary for engineers to construct barbed-wire fences. Figure 69 is a diagram of a double-apron fence. The layout of such a fence is complicated and is not taken up here. However, there are numerous little jobs in the construction of a barbed-wire double-apron fence which may cause trouble if they are not accomplished correctly. These are mostly tricks of fastening wire to posts. Figure 70 shows a screw-type picket. Practice making the connections shown on figures 71 and 72. Figure 73 shows how to roll a barbed-wire bobbin.

b. Clearing barbed wire is sometimes an engineer's job. Figure 74 shows how to cut barbed wire so as to make as little noise as possible. When speed is more important than silence, barbed wire is blown by means of a bangalore torpedo. (See par. 48.)

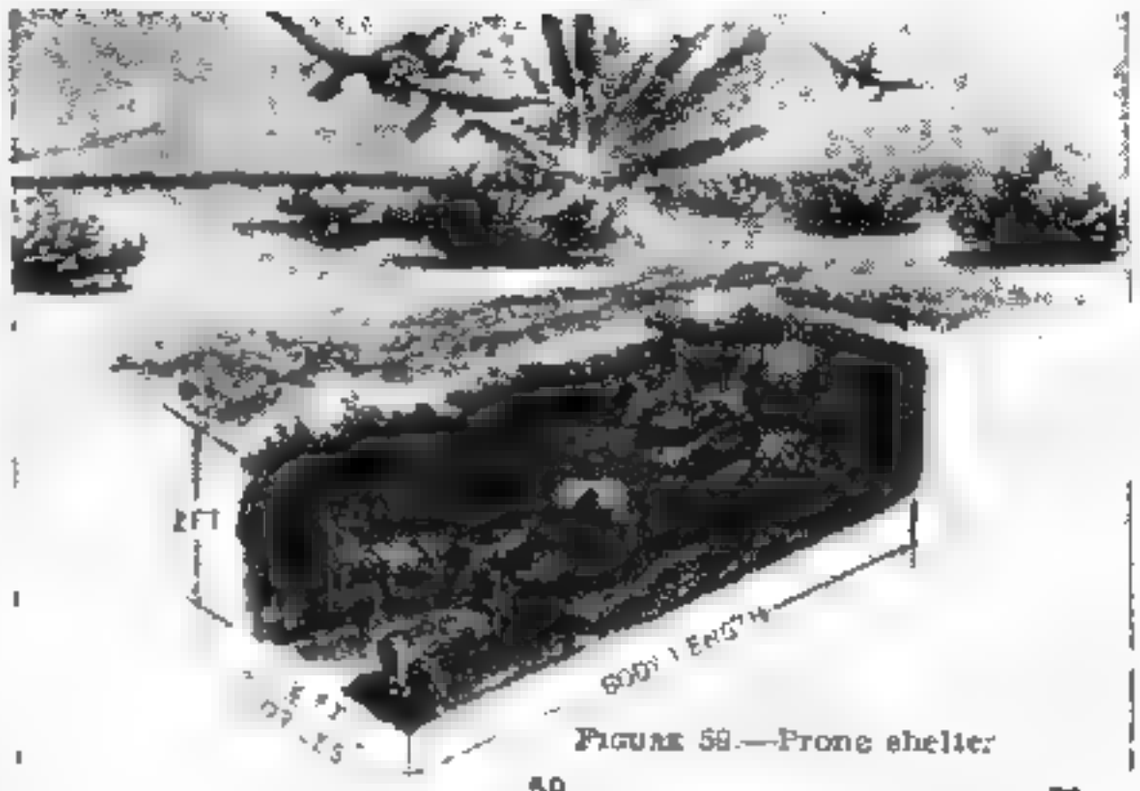


FIGURE 59.—Prone shelter

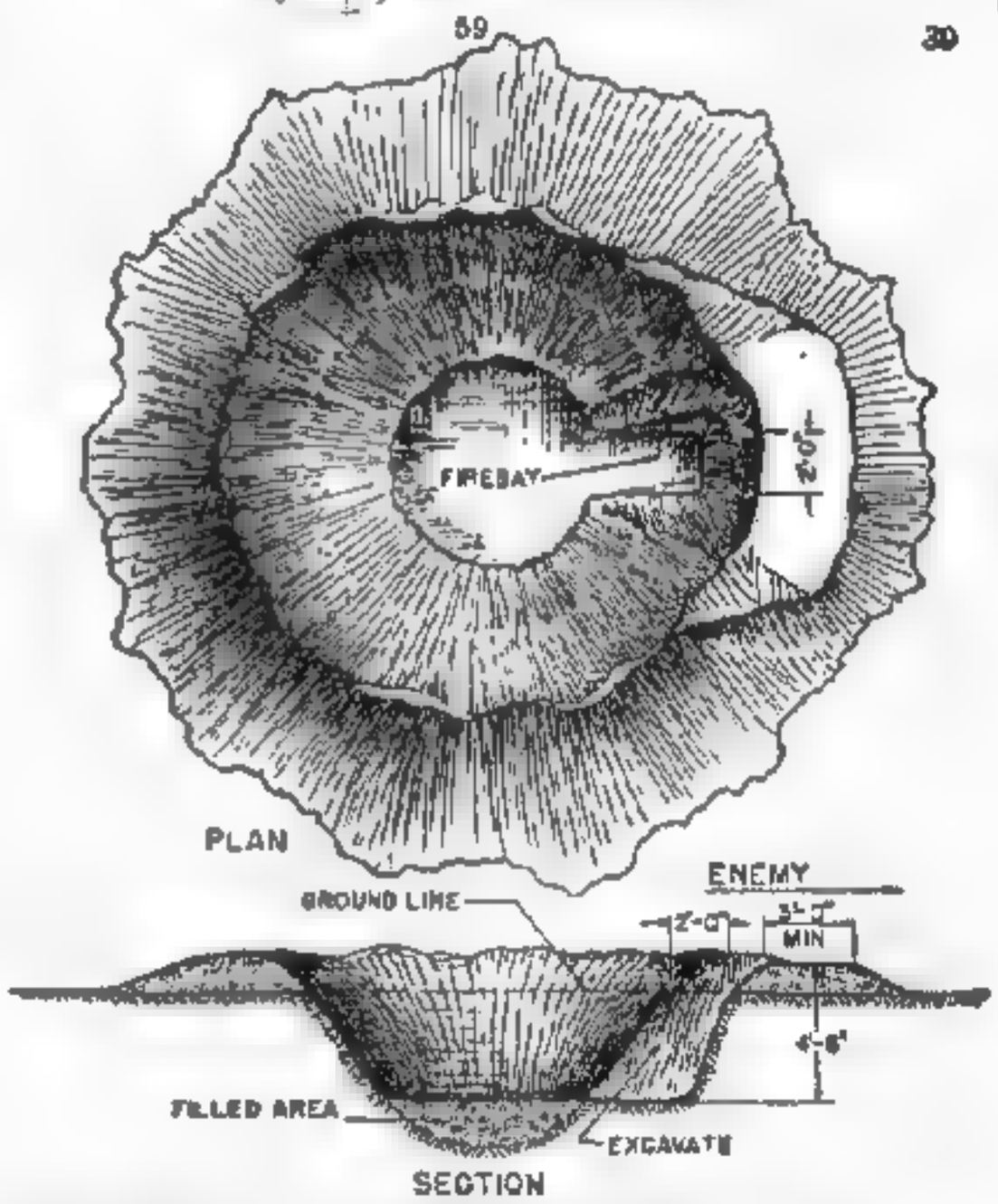
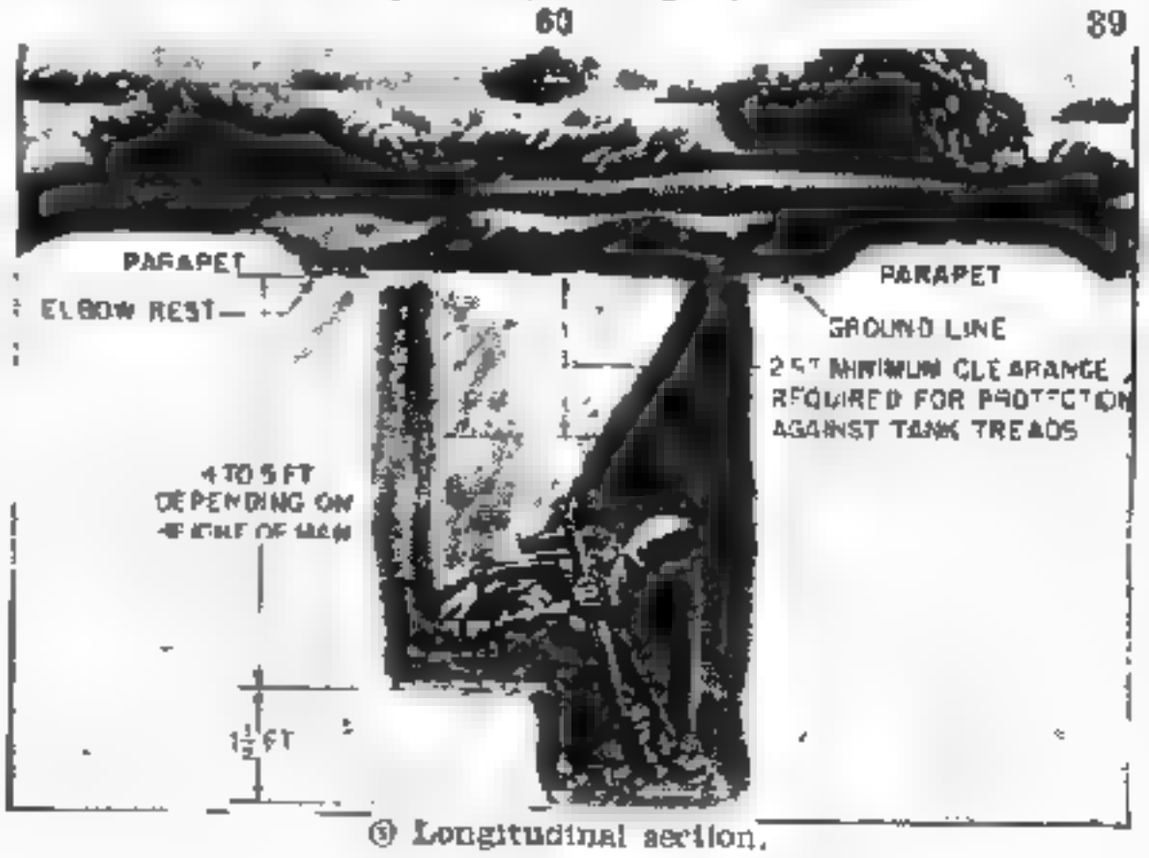


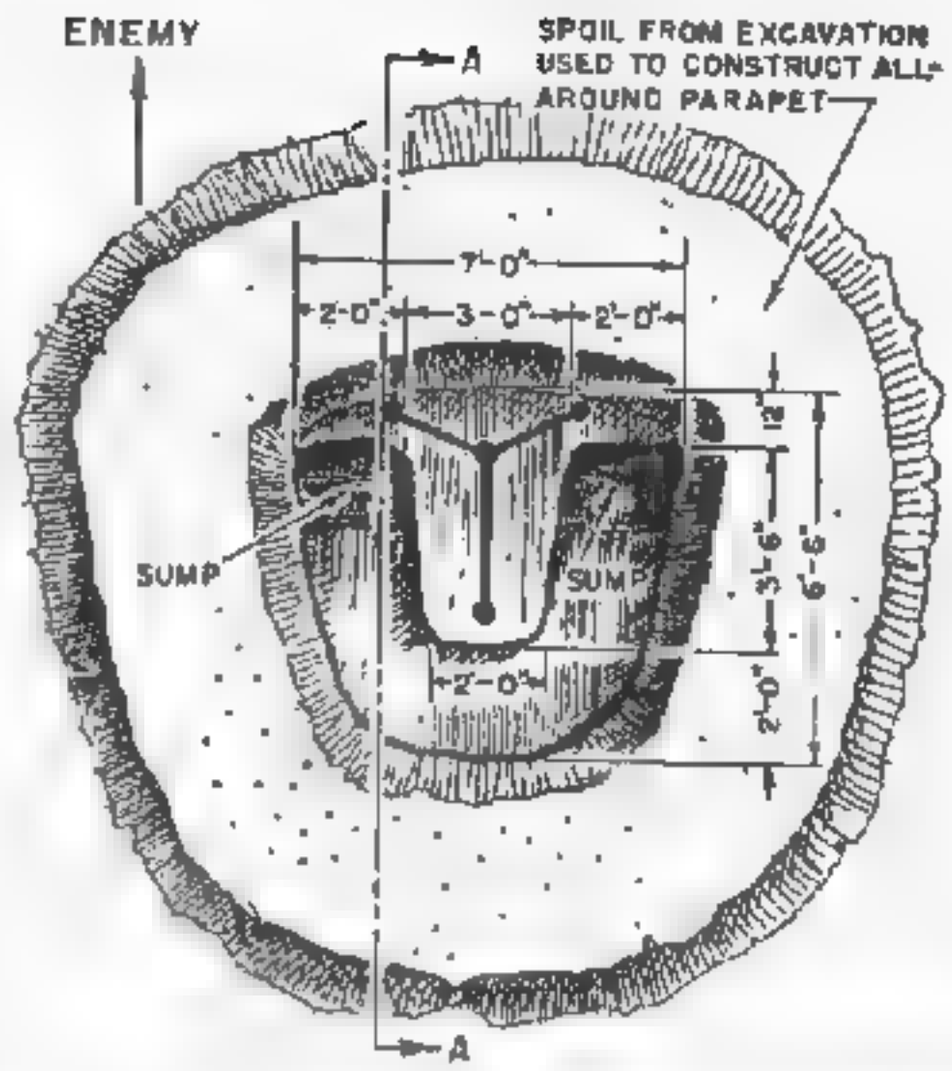
FIGURE 60.—Shell-hole position, showing improvements for one man



③ Longitudinal section.

(A) Cross-section view

FIGURE 61.—One-man fox hole



PLAN

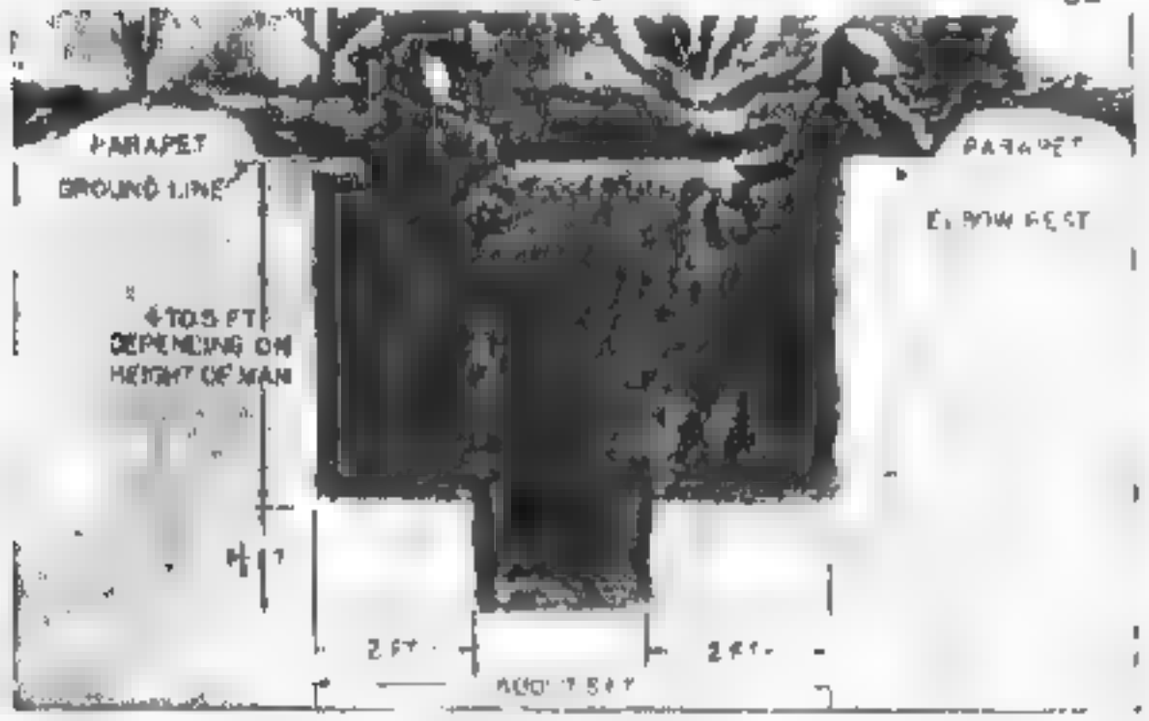


FIGURE 62.—Two-man fox hole.

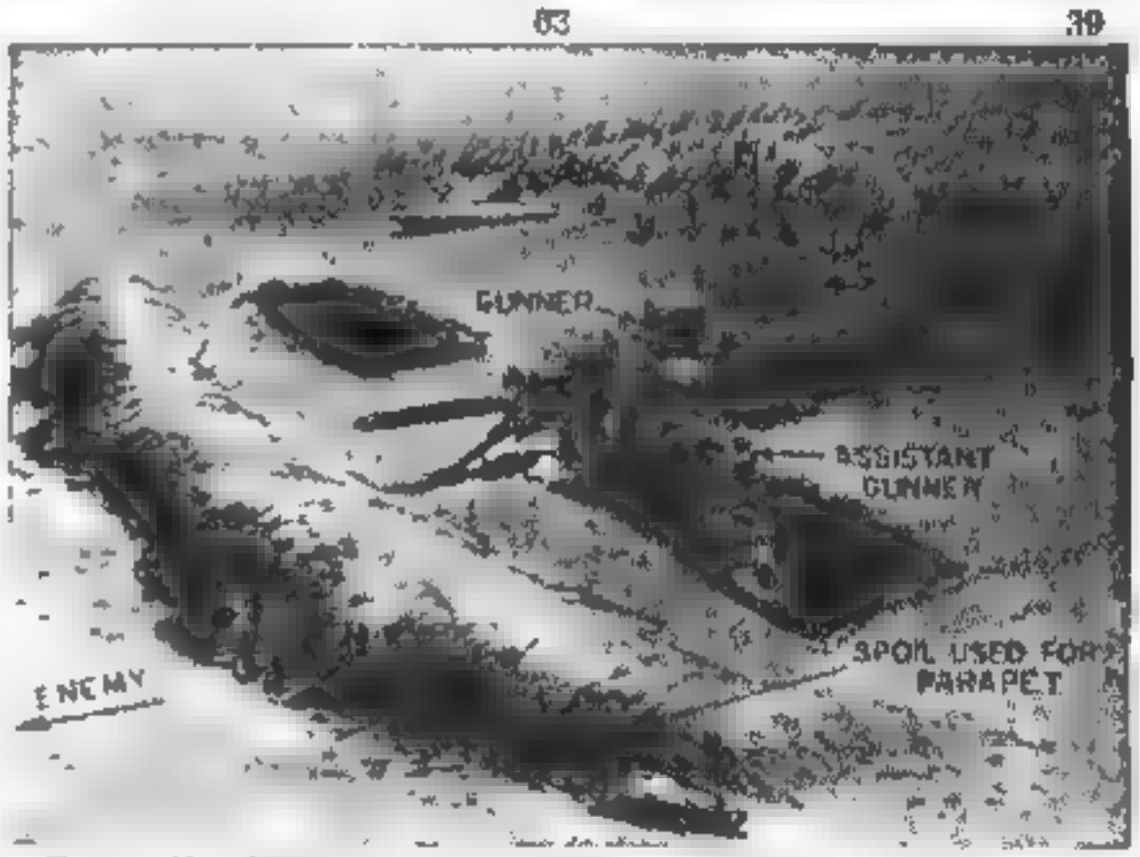
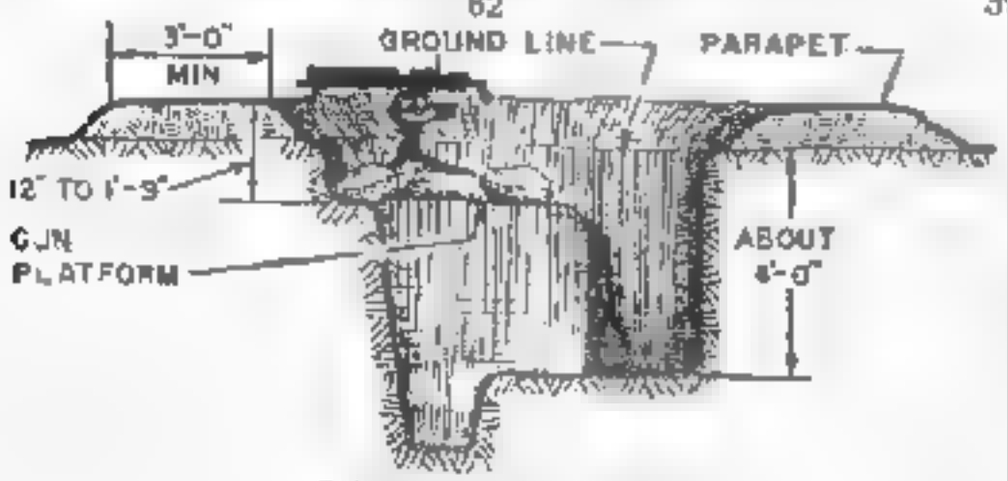


FIGURE 65.—Caliber .30 machine-gun (light) emplacement, fox-hole type.

FIGURE 63.—Caliber .30 machine-gun (heavy) emplacement, open shallow type.



SECTION ON LINE "A-A"

FIGURE 64.—Caliber .30 machine-gun (heavy) emplacement, open standing type.

FIGURE 66.—Caliber .30 machine-gun (light) emplacement, open standing type.

64 39

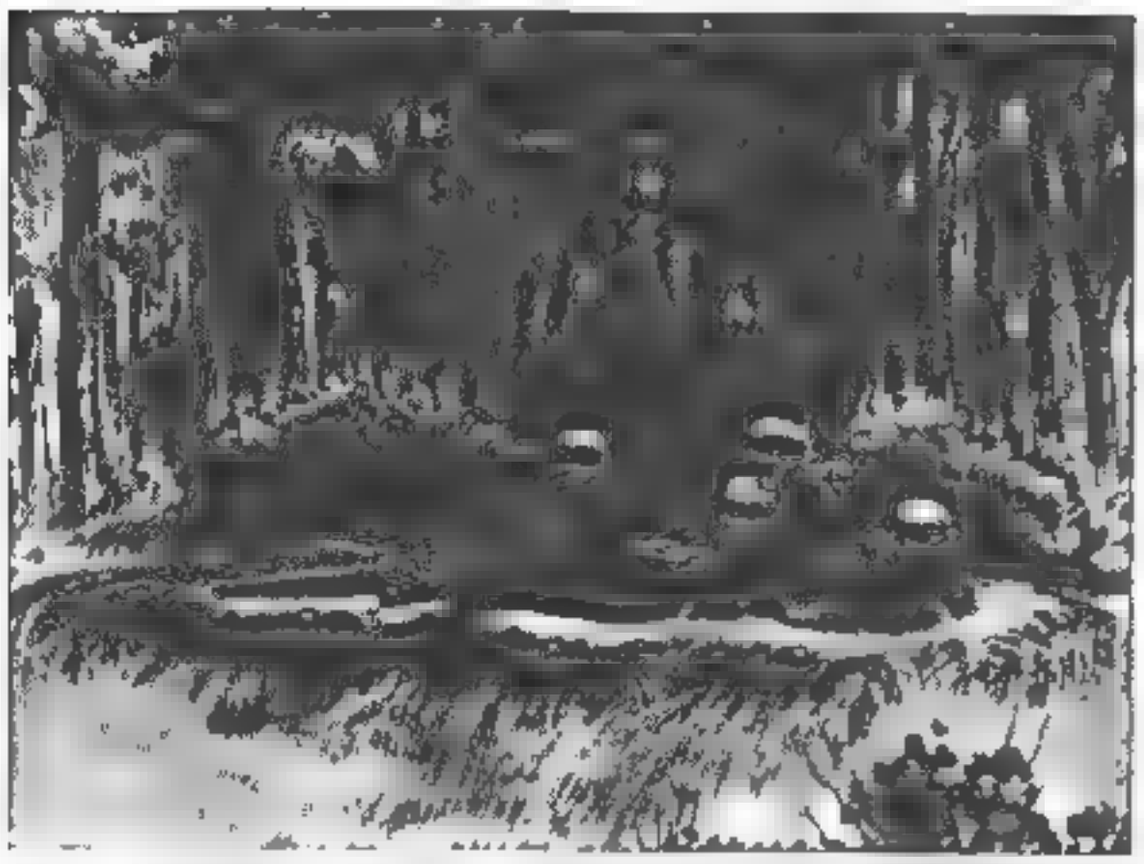


FIGURE 67.—37-mm antitank gun and emplacement

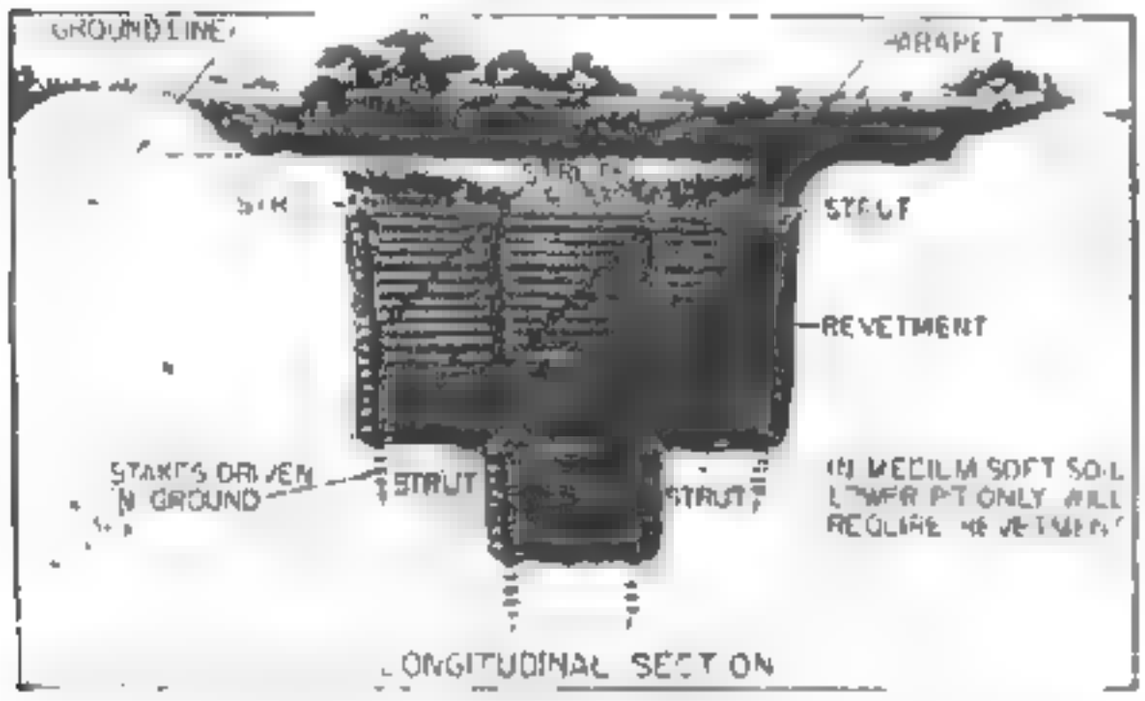
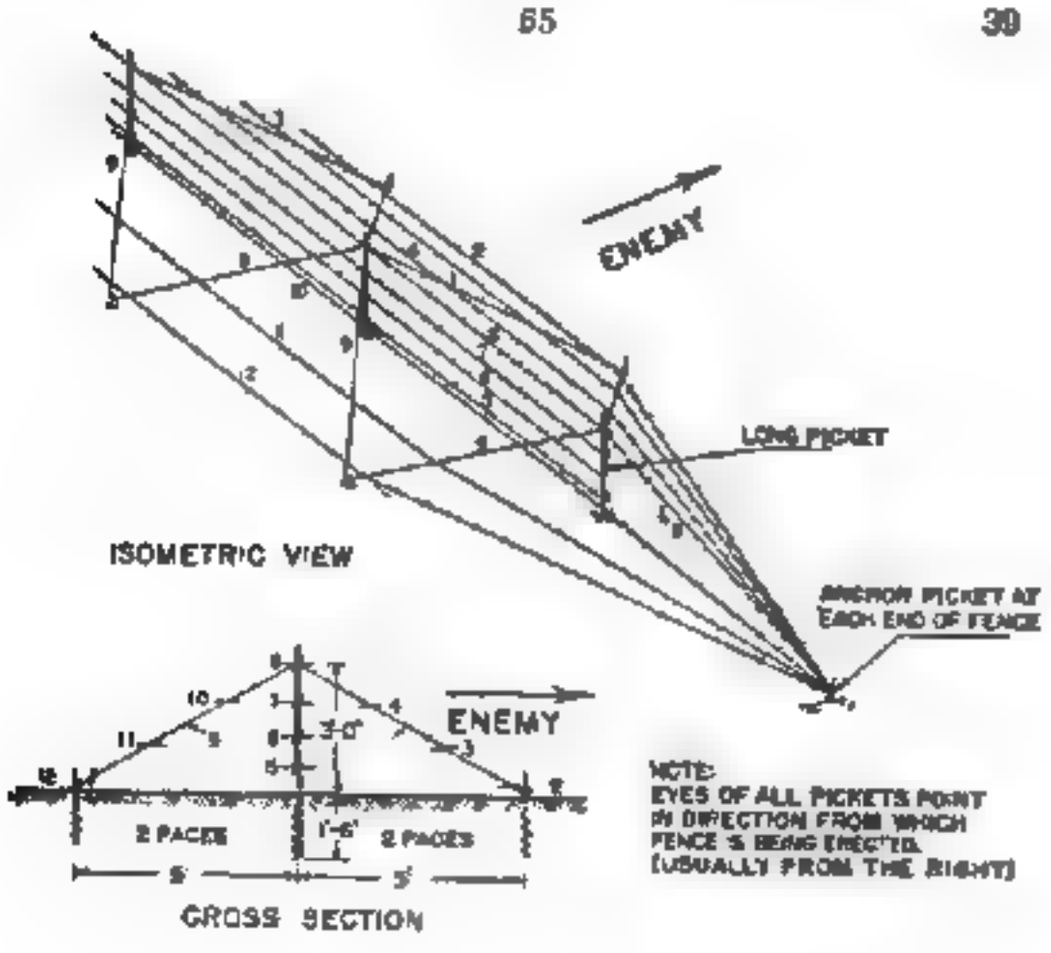


FIGURE 68.—Two-man fox hole, showing method of revetment.

65 39



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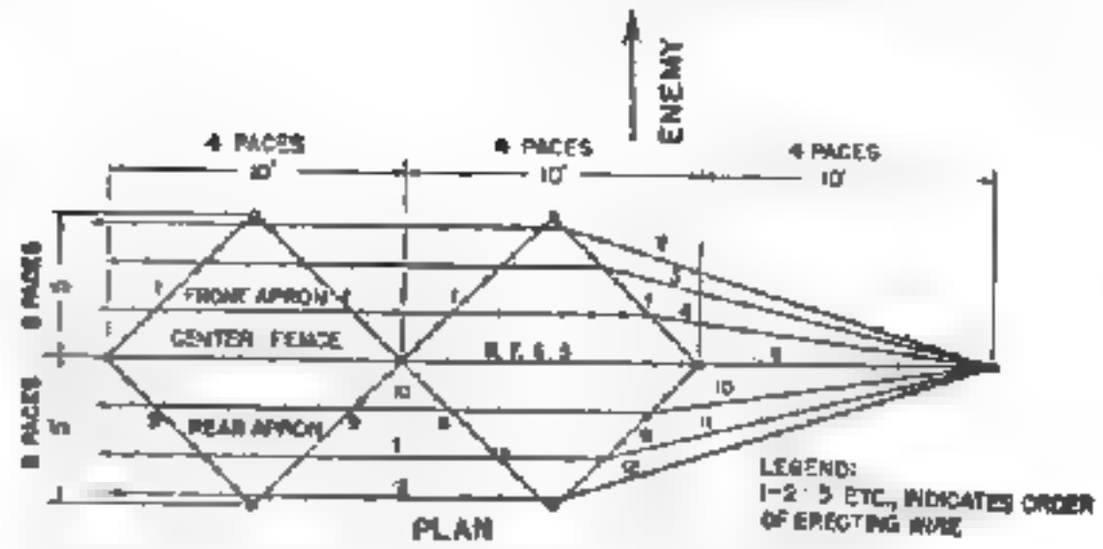


FIGURE 69.—Barbed wire double-apron fence.

FIGURE 70.—Long screw-type picket.

67 39

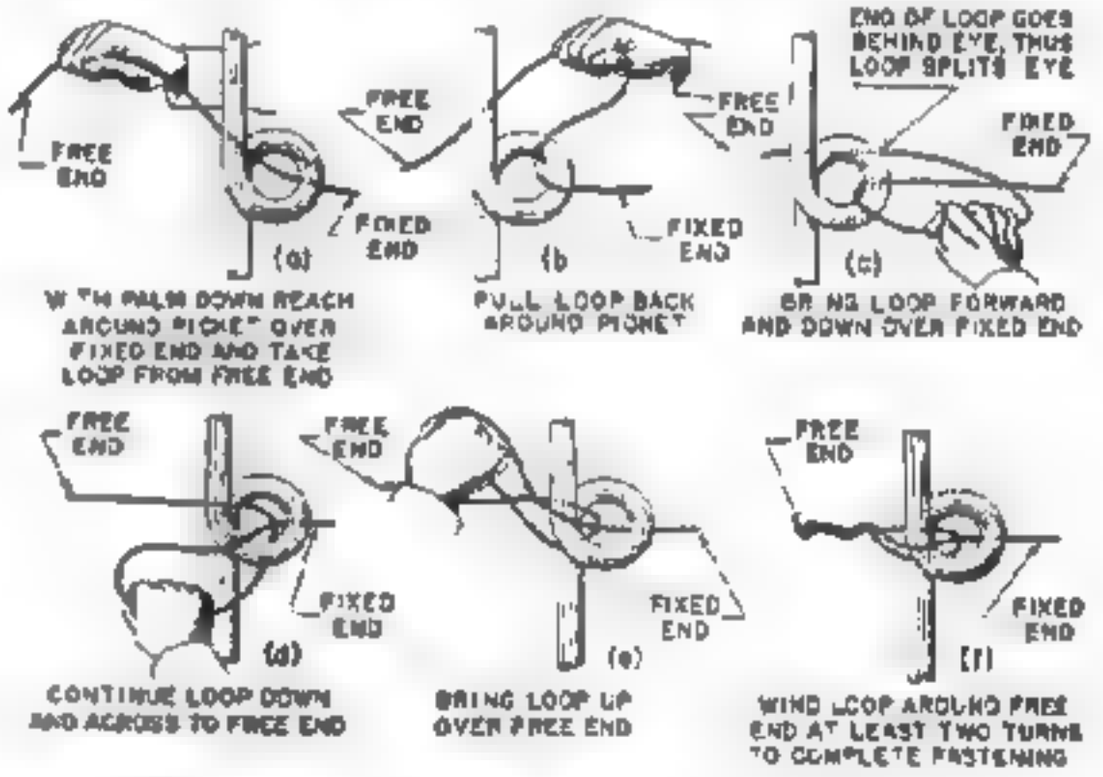
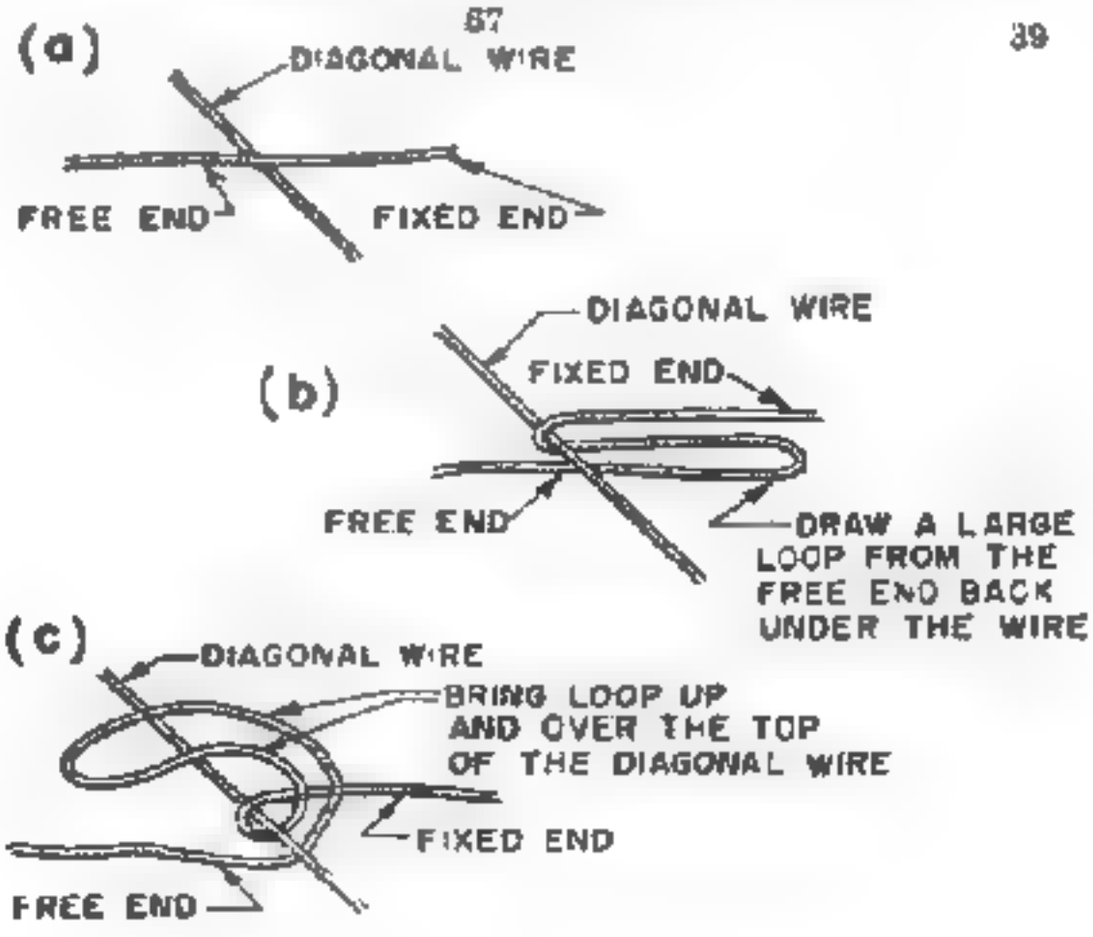


FIGURE 71.—Tying barbed wire to pickets.



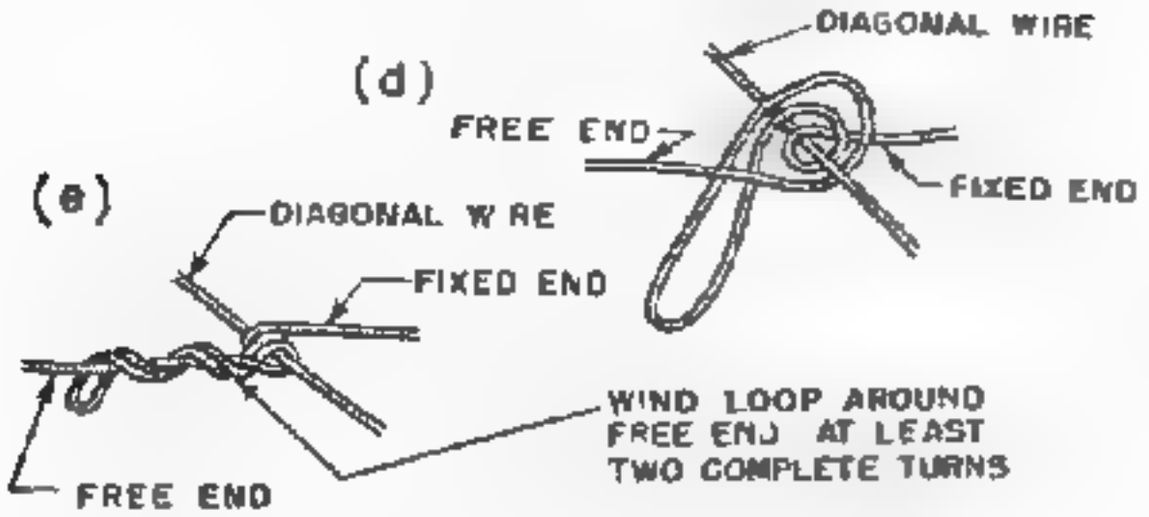
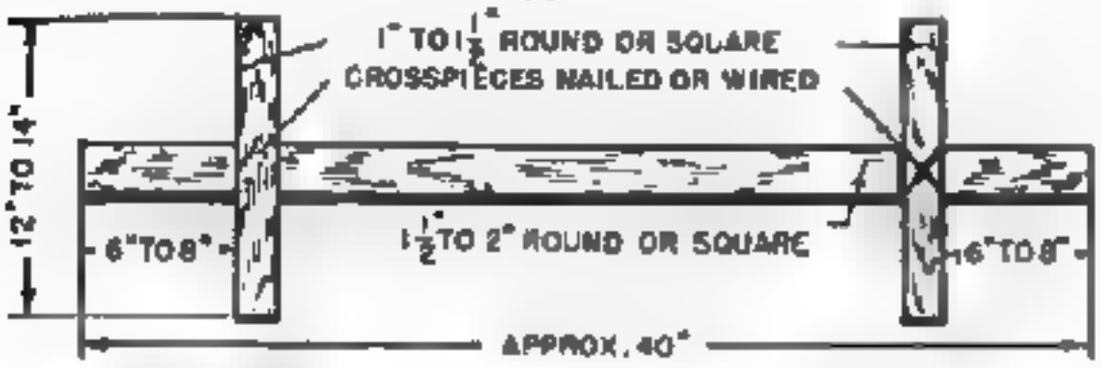


FIGURE 73.—Fastening horizontal wire to diagonal wire.

68 39



WINDING BOBBIN FROM REEL

FIGURE 73.—Making bobbins.

69 39

FIGURE 74.—Cutting barbed wire.

70 40–42

CHAPTER 5

CAMOUFLAGE

■ **40. WHAT IS CAMOUFLAGE?**—*a.* Camouflage is a weapon—one of the most important we have. It consists of all the work we do to hide ourselves and our equipment from enemy observation. By means of careful camouflage we can protect ourselves, confuse the enemy, cause him to waste valuable ammunition, or make him fall into a trap.

b. Remember that if the enemy can't see us, he can't hit us effectively. If you learn to understand and to carry out the important principles of camouflage, you can give your Army a head start on the enemy. However, if you, an individual soldier, make a single mistake, you may give away the position and plans of your whole battalion. That's how important camouflage is.

c. Everyone in the Army must know how to use camouflage But as an engineer you are expected to be an expert at it We must learn this job so well that when other branches of the service come to the engineers for camouflage advice and help, we will be able to do the job. *Make good camouflage an intimate part of your daily life.*

d. FM 21–45 and 5–20 contain additional information about deceiving the enemy by means of camouflage. Ask your platoon leader for these manuals and read them carefully

■ **41. INDIVIDUAL CONCEALMENT.**—You must learn to hide your own presence and movements. Remember, you can be seen from both the ground and the air. The aerial observer is one of our deadliest enemies, but you can beat him if you are careful

■ **42. HINTS ON INDIVIDUAL CAMOUFLAGE.**—*a. Select your positions and routes of advance beforehand.*

b. Move rapidly between well selected positions by "leaps and bounds."

c. Learn to work and move silently.

71 42–44

d. Keep in shadows (fig. 75).

e. Break up form. Use branches and leaves to break up your outline (fig. 76).

f. Break up solid areas of color and blend them with their surroundings. Camouflage your tent with natural materials (fig. 78).

g. Avoid a reflected light or shine Paint or darken your face to confuse enemy snipers.

h Hide earth you dig from ground and change the regular outline of your fox hole (fig. 77).

■ **43. CAMOUFLAGE DISCIPLINE.**—In modern war, not only individuals but whole armies, their buildings, guns, and trucks, are camouflaged. Around installations it is important that the pattern of the ground be unchanged, especially as viewed from the air. *A single set of footprints in a field is visible from the air.* A single flashing mess kit can reveal the position of a company. Observe all rules of camouflage discipline.

a. Don't make new tracks.

b. Keep on existing paths and roads.

c. Don't throw refuse or spoil where it can be seen

d. Do nothing that will change appearance of ground from the air.

■ **44. ARTIFICIAL MATERIALS.**—*a.* Sometimes artificial materials must be used in camouflage. The Army furnishes nets of various sizes for this purpose. Learn to use them properly. The two main camouflage nets issued by the

Army are shrimp nets (with ¼-inch mesh), which are used only as drapes, and fish nets, which are *garnished* with strips of colored cloth and may be used either as drapes or flat-tops. Garnishing means weaving the net so as to make it less transparent (fig. 79). Use the nets so that they conceal the *shape* of your vehicle, gun, or shelter, and so that

72 44

① Wrong Scouts are silhouetted against sky.

② Right. Scouts in shadows with dark foliage as background.

FIGURE 75.—Use shadow and terrain in observing.

73 44

③ Wrong. No camouflage. Gun and gunners conspicuous.

④ Right. Twigs, leaves, branches used to blend emplacement against background.

FIGURE 76.—Use natural materials for camouflage.

74

⑤ Uncamouflaged

⑥ Spoil carefully disposed of Fox hole covered with shrubs and grass

FIGURE 77.—How to use natural materials to conceal fox holes

⑦ Wrong

⑧ Right

FIGURE 78.—Camouflage your tent with natural materials Note characteristic black telltale triangular shadow of uncamouflaged tents on left

no betraying *shadow* is cast (fig 80).

b. There are many kinds of artificial camouflage materials

and many ways to use them. As you learn about them in training take note of details which will make your camouflage successful.

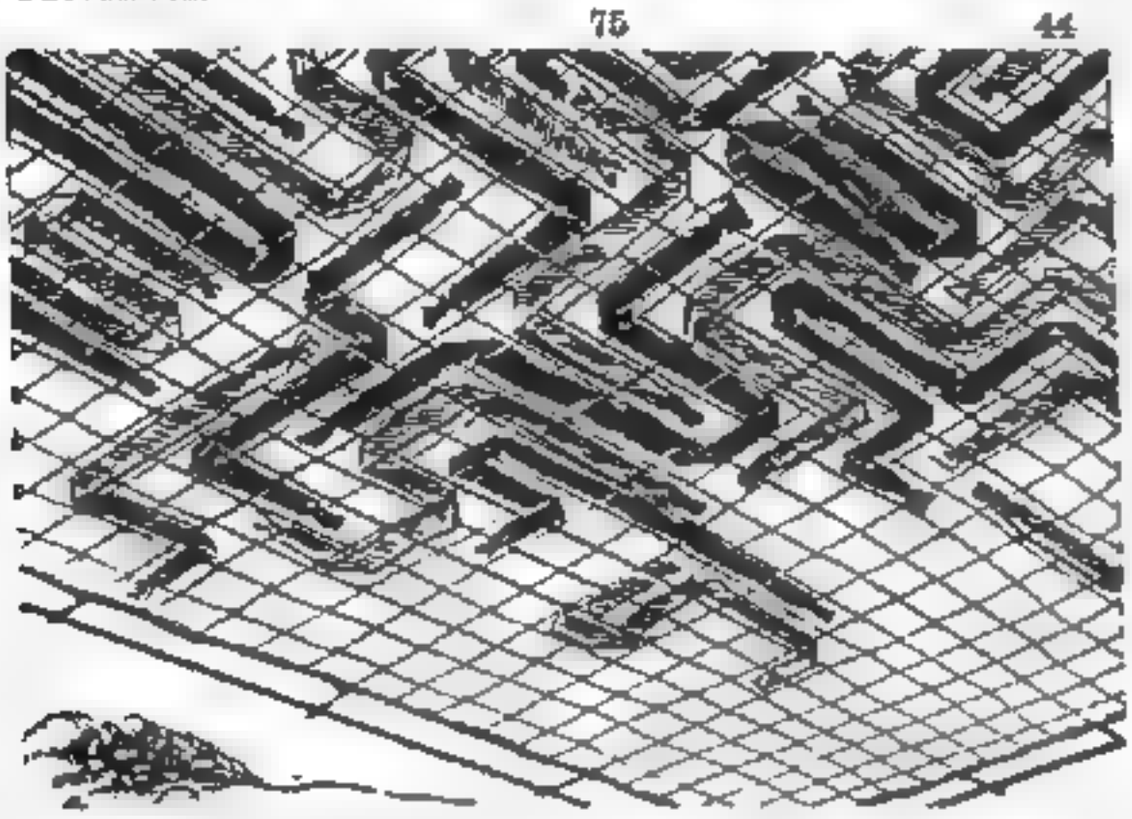
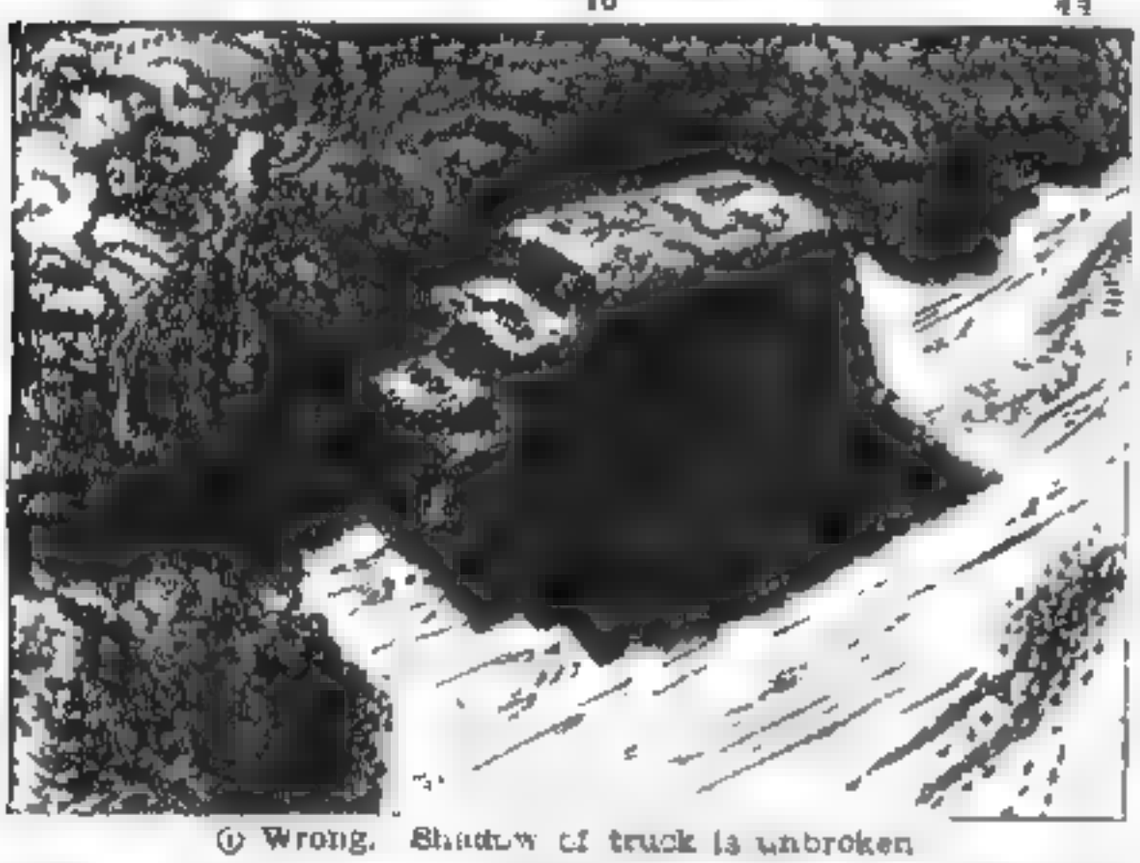
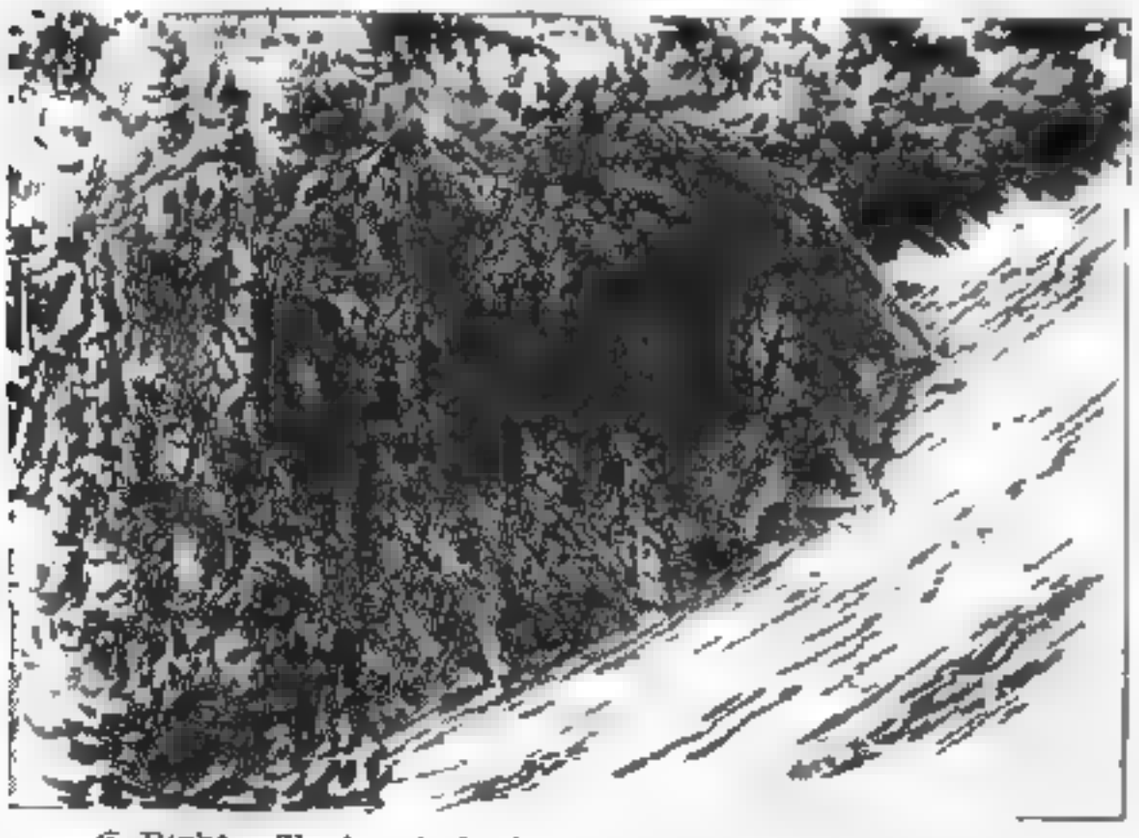


FIGURE 79.—Detail of garnished net



① Wrong. Shadow of truck is unbroken



② Right. Shadow is broken up and truck is concealed.

FIGURE 80.—Use of camouflage net on vehicles.

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CHAPTER 6

EXPLOSIVES AND DEMOLITIONS

■ **45. THE JOB OF DESTRUCTION.**—*a.* As an engineer soldier, one of your most important jobs is the handling of explosives and demolition tools. It takes training to become an expert demolition man. There is a great deal to learn. In this chapter you will find enough fundamentals to give you a good start. With these essentials and with experience you can gradually become an expert.

b. You must learn this job thoroughly. It is a great responsibility. When you are given the job of blowing up a bridge, a road, or a building, that bridge, or road, or building *must be destroyed at the specified time.* There can be no mistakes. Demolitions are usually ordered at critical times; and the failure of a single demolition may cost the lives of hundreds of men. You must not fail.

■ **46. EQUIPMENT.**—Demolition sets are issued to all general engineer units and many special engineer units. Each set includes a supply of explosives and the necessary tools and equipment for preparing, priming, and firing demolition charges. Earth-drilling tools, wood augers, and rock drills required for placing charges are available in pioneer and carpenter sets.

■ **47. EXPLOSIVES.**—*a. TNT.*—(1) TNT (trinitrotoluene) is the standard explosive for Army use. It is issued in ½-pound blocks encased in a cardboard container closed at both ends with lacquered tin (fig. 81). One end of each block has a cylindrical hole, approximately ⅝ inch in diameter and 2⅛ inches long, for receiving the cap.

(2) TNT is one of the safest explosives to handle, if you know how to use it. It is insensitive to shock and will not detonate even under strong pressure or severe blows. It requires the special issue cap or detonating cord to set it

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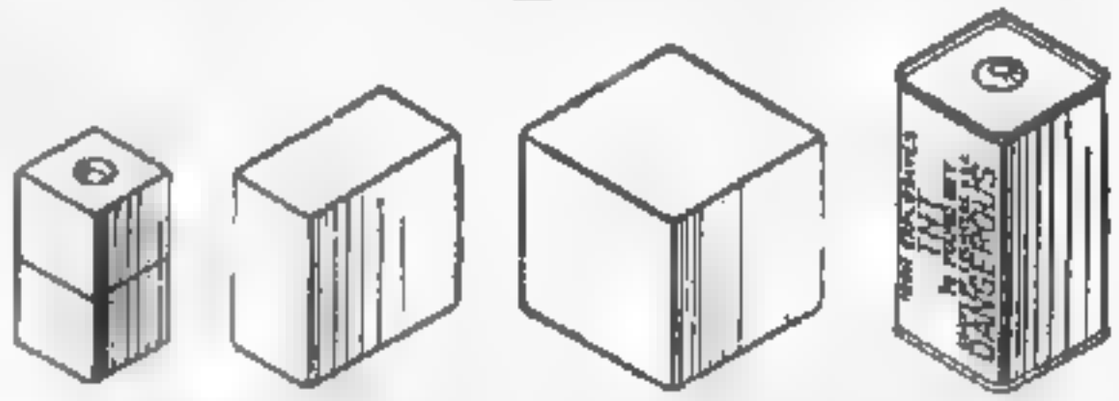

FIGURE 81.—Packages of nitrostarch, and TNT: ¼-, ½-, and 1-pound packages of nitrostarch, and ½-pound block of TNT

off. In small quantities it can be burned without danger of detonation, but in large quantities the heat generated will raise the temperature to the detonating point. TNT will not dissolve in water and hence is suitable for underwater demolition work.

b. Nitrostarch.—Nitrostarch is issued in ½-pound, cardboard-covered blocks of the same size and shape as TNT and in 1-pound paper-wrapped packages. Each of the 1-pound packages is made up of four ¼-pound packages, which, in turn, are made up of three ⅓-pound blocks. Each of these blocks has a cap hole extending all the way through it. Nitrostarch is similar in many respects to TNT.

c. Dynamite.—Dynamite is issued in approximately ½-pound sticks, approximately 1¼ inches in diameter and 8 inches in length. Fifty percent straight dynamite is equal in strength (pound for pound) to TNT. It is much more sensitive than TNT and may be detonated by a blow with a metal instrument, or by flying sparks struck from metal striking metal. When frozen it is especially dangerous and must be handled with extreme care.

d. Ammonium nitrate cratering explosive (*fig. 94*).—Ammonium nitrate cratering explosive is issued in 40-pound

charges, each packed in a cylindrical container of tin or other moistureproof material of equal strength. The metal container is about 8¼ inches in diameter and 17 inches in height; another type of container, made of waterproofed cardboard, is 7 inches in diameter and about 21 inches high. Two tubes are secured to the outside wall of each container,

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one for receiving the detonating cord, and the other the special cap. If exposed to air, ammonium nitrate explosive absorbs moisture rapidly; consequently, it must never be removed from the container. It is used principally in making crater obstacles for tanks and other motorized vehicles.

■ 48. BANGALORE TORPEDO.—*a.* The bangalore torpedo is a metal tube or pipe filled with explosives. Its primary uses are to cut gaps in barbed wire obstacles and to cause detonation of mines. The standard bangalore torpedo, about 2 inches in diameter, is issued in 5-foot watertight sections already filled with explosives. Sleeves are provided for connecting sections to extend torpedoes to any desired length. By fastening the rounded nose on the forward end, you can push the torpedo through a band of barbed wire without getting it caught on the wires.

b. To explode the torpedo, an electric or nonelectric cap, or primacord, is inserted in the cap well in the trailing end of the torpedo. When several sections are joined to form a long torpedo, it is necessary to place a cap only in the last section, since detonation of one section will cause the whole torpedo to explode. If standard-type torpedoes are not available, you can make bangalore torpedoes by filling a pipe (for example, a 2-inch water pipe or an old drain pipe) with explosives; the ends are closed with wooden plugs, and one end is primed by making a hole through one of the plugs; a primer made with TNT block and primacord is placed inside the torpedo and the primacord end is drawn through the hole in the wooden block.

c. Remember that each 5-foot section of the bangalore torpedo is loaded with about 10 pounds of high explosive, and the same precautions in handling and firing must be taken as when other military high explosives are used.

■ 49. FIRING MATERIALS.—*a. Caps* (figs. 82 and 83).—Caps are placed in charges to set them off. Standard commercial caps will not detonate TNT or ammonium nitrate cratering charge; therefore the army has adopted a special cap. Caps are classified as electric or nonelectric, depending on whether they are set off by electricity or fuze. Both types must be

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handled with great care, because they may be set off by dropping or hitting them, or exposing them to excessive heat.

b. Exploders.—Exploders are used to supply electric current to set off electric caps. The 10-cap exploder is operated by a quick twist of the handle. The 30-cap exploder is operated by slowly pulling the handle all the way up and then pushing it all the way down as fast and as hard as possible.

c. Firing wire.—Firing wire, carried on a metal reel, is used to connect the exploder to wires of electric caps placed in charges. It is issued in 500-foot lengths so that a man may fire the charge from a safe distance. Cap wires are connected to the free end of the firing wire, and the exploder is connected to the end which is fixed to the metal reel. When extremely large charges or steel-cutting charges are being fired, two or more reels of wire may be connected so as to enable the firer to fire the charge from a distance of 1,000 feet or more.

d. Time fuze.—A time fuze is used to set off nonelectric caps. It consists of a train of black powder contained in a waterproofed textile covering which may be either white or orange. When using a time fuze, cut it to the desired length and crimp one end in the nonelectric cap. Light the other end with a match or fuze lighter after the explosive charge has been prepared. Always be sure to use a fuze long enough to enable you to reach a place of safety before the charge explodes. A time fuze burns at the rate of about 2 feet per minute.

e. Fuze lighter.—The fuze lighter (fig. 84) is used to light a time fuze. The open end is placed over the end of the time fuze where it is held in place by means of teeth inside the fuze lighter. These teeth permit the fuze to enter, but are inclined so as to bind the fuze and prevent its removal. It is unnecessary to crimp the lighter. Pulling the handle causes a flame inside the lighter which lights the fuze even in wet or windy weather, if the lighter and the powder train in the fuze *have been kept dry*. The fuze lighter should be set off by means of a steady pull (*not a jerk*). (Fig. 100 shows how to improvise a fuze lighter.)

f. Detonating cord.—A detonating cord consists of a train

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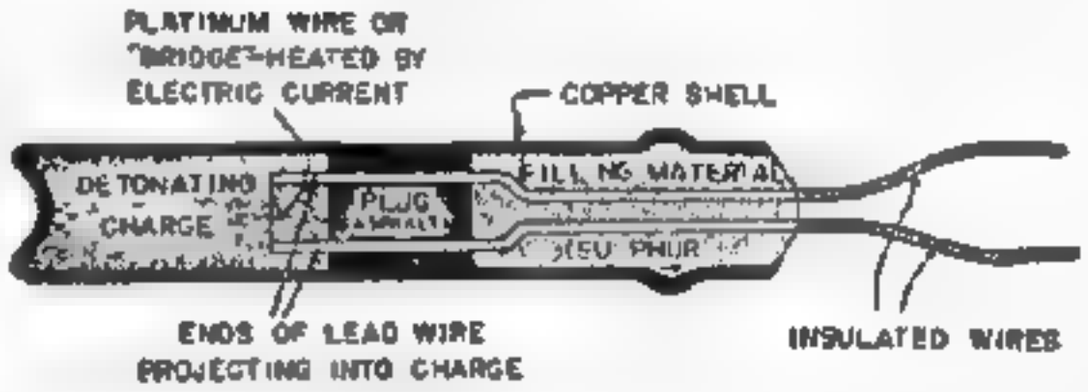
PICTURE 82.—Nonelectric cap.



PICTURE 83.—Electric cap.

of high explosive contained in a waterproofed textile covering. It is set off by a cap taped or tied to it. Instead of burning like a time fuze, it explodes like other high explosives and will set off other explosives properly connected to it. It is used mainly to set off a number of charges at one time or to fire a charge in a deep hole. Its action is instantaneous; therefore, whether the detonating cord is fired by an electric or nonelectric cap, the firer should take the same precautions as if the cap were placed directly in the charge.

g. Crimper.—The crimper (fig. 85) is used to crimp the open end of the nonelectric cap around the time fuze and to cut time fuze. One leg of the handle is pointed for use in making holes for caps in dynamite, and the other leg has a screw-driver end.

h. Tools for boring holes.—Holes in earth, concrete, rock, or other material in which explosive charges may be placed are made with many kinds of hand and power tools. Miners' tools are shown in figures 86, 87, and 88. Tools other than those shown here include the air compressor, with its rock and pavement-breaking attachments (see figs. 30 and 31), and two types of earth auger, one of which drills holes 6

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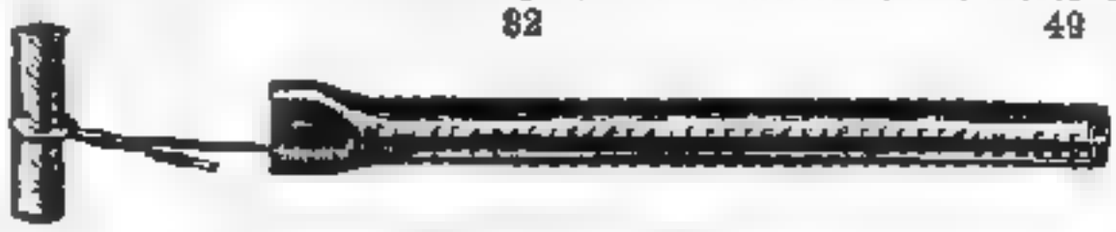


PICTURE 84.—Fuze lighter.

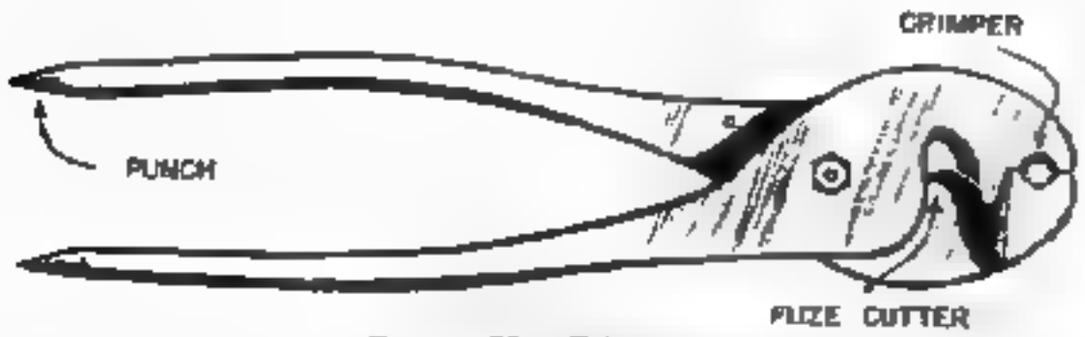


FIGURE 86.—Crimper.

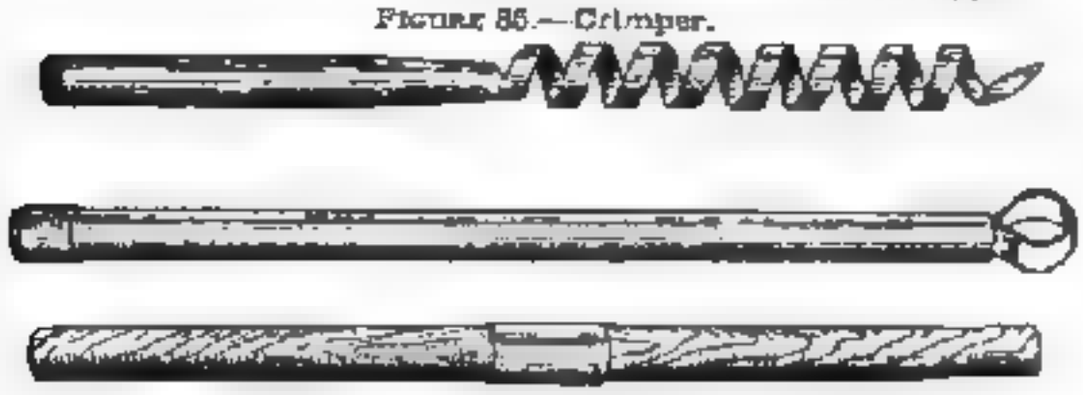
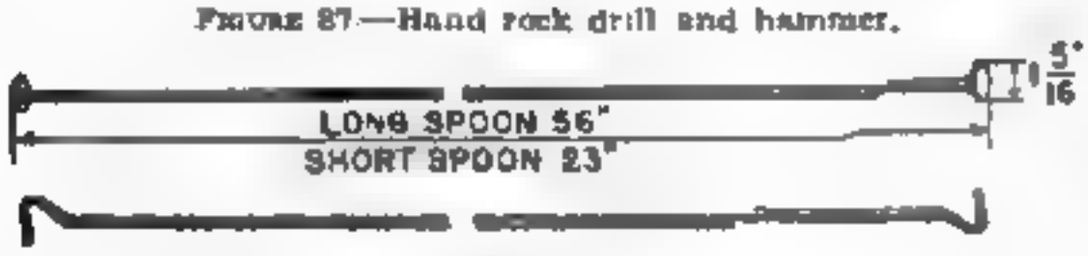


FIGURE 86.—Mining drill.

FIGURE 87.—Hand rock drill and hammer.



83 49–50

inches in diameter and the other holes 10 inches in diameter. (See fig. 17.) These augers are useful in drilling holes to place charges for road craters.

■ 50. PRIMERS.—A primer is a block or package of high explosive with a cap placed in it, or detonating cord tied through or around it. A charge is primed by placing in it a primer prepared as above. The purpose of the primer is to insure detonation of charge. The cap or detonating cord sets off the block or stick of explosive in which it is placed, which in turn sets off the remainder of the charge.

a. Primer of TNT or dynamite, with nonelectric cap and fuze.—Cut fuze off *square* with fuze cutter. See that no dirt is in the open end of the cap, then slip it over the fuze as far down as it will go. Hold the fuze in one hand and crimp cap to fuze with cap crimper, making crimp near open end of cap. Next, put cap with fuze attached into the hole in TNT block or dynamite stick (figs. 89, 90, and 91). The twine holding the cap in place must be tied so that when the fuze is pulled, the twine takes the pull and the cap is not moved in the hole.

b. Primer of TNT block or dynamite, with electric cap.—Place cap in hole in TNT block, making a clove hitch in the cap end of the lead wires. Pass this loop around TNT block and pull tight, leaving the wire slack from the loop to the cap. The same procedure is used with a dynamite stick (see fig. 92); another method is to tie a preliminary half hitch near the bottom of the stick before tying the clove hitch near the top.

c. Primer with detonating cord and TNT block.—Tie cord directly to the TNT block as shown in figure 93. To do this, tie one-half of a clove hitch, take one full turn around the block, then tie the second half of the clove hitch. Pull all three turns tight so they will fit *snugly against each other and against the block.*

d. Primer with ammonium nitrate cratering charge.—For electrical firing place an electric cap in the cap well provided on the side of the container. Make several turns with the lead wires around the knob above the cap well and pull tight, so that a pull on the lead wires will not dislodge the

84 50–51

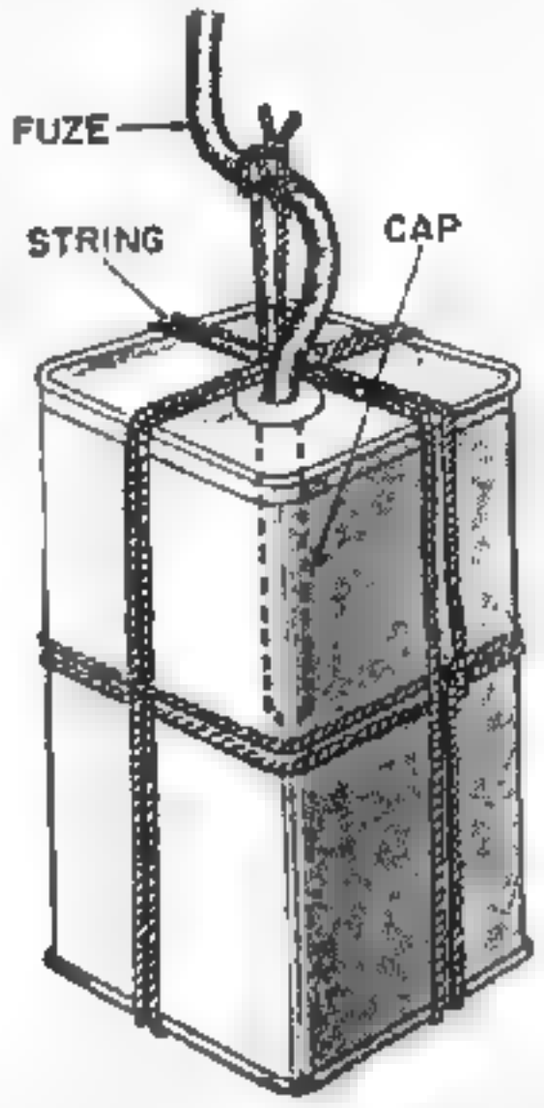


FIGURE 88.—Primer made of TNT block and nonelectric cap.

cap (fig. 94). To make a primer using detonating cord, pass the detonating cord all the way through the tunnel (from top to bottom) on the side of the container and tie an overhand knot in the lower end to prevent the cord from pulling out of the tunnel. Both means of detonating should be used simultaneously. Do not use detonating cord or electric-cap leads to lower the ammonium nitrate cratering charges into holes; use a cord attached to the ring in the top of the charge.

■ 51. DETONATING ASSEMBLY.—Detonating assemblies may be prepared prior to an operation so that the detonating device may be quickly attached to an emplaced charge such as a

85 51–52

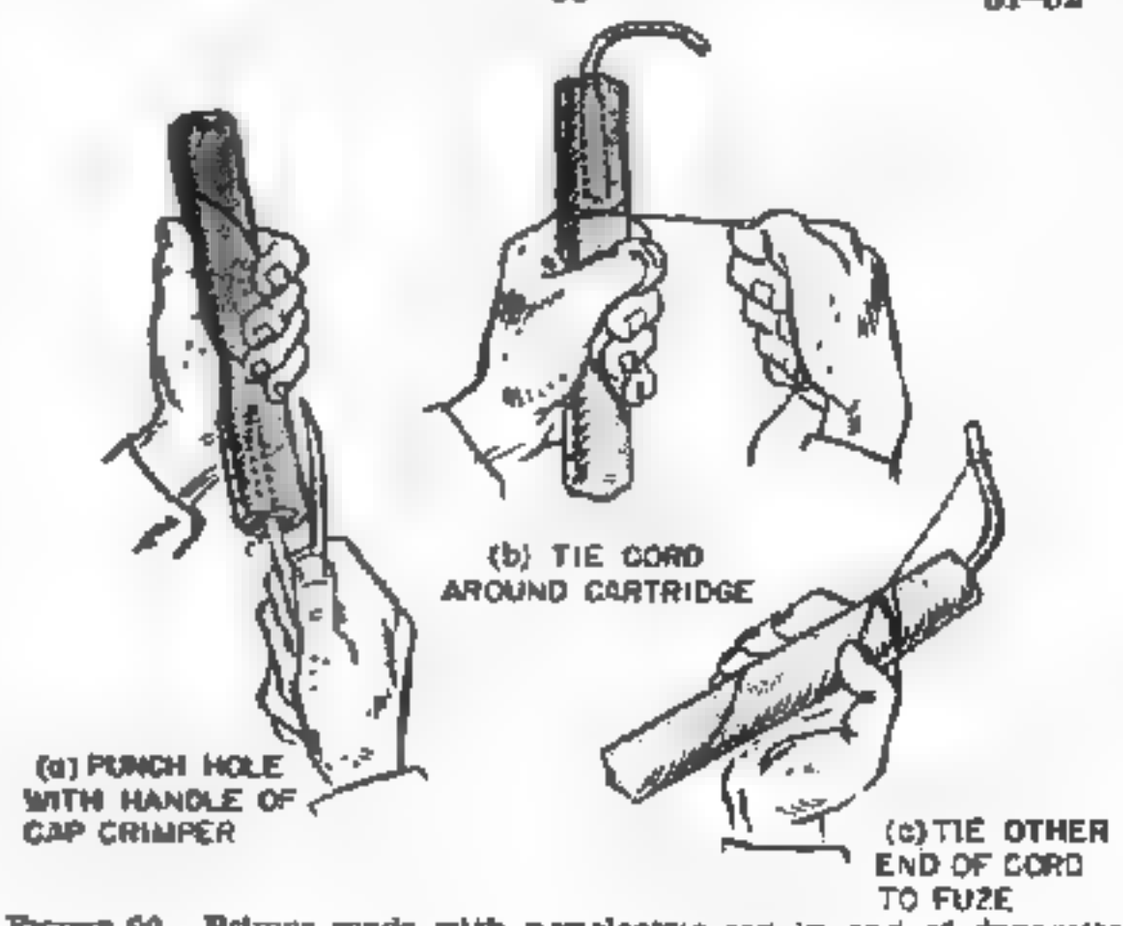


FIGURE 90.—Primer made with nonelectric cap in end of dynamite stick.

crater explosive or a bangalore torpedo. The assembly is made by binding a nonelectric cap to a piece of detonating cord (as shown in fig. 96), allowing sufficient length of detonating cord to tie a square-knot splice to the charge. Time fuze is crimped to the cap, and a fuze lighter is crimped to the other end of the fuze. (See fig. 95.)

■ 52. NONELECTRIC CONNECTIONS.—*a. To attach cap (electric or nonelectric) to detonating cord.*—Lay the cap and time fuze alongside the detonating cord, with the cap pointing in the direction of the charge. Bind the cap and detonating cord securely together, using either friction tape or twine, as shown in figure 96.

b. To splice detonating cord.—Use a square knot to tie two ends of detonating cord together. The loop in the end of each piece of detonating cord must be at least 6 inches long (fig. 97).

c. To connect a branch line of detonating cord to a main line.—Use two half hitches to tie a branch line to a detonating-cord main line. Make sure that the branch line leaves the main line at an angle of 90°. Leave 6 inches of the running end of the branch line free beyond the tie (fig. 98).

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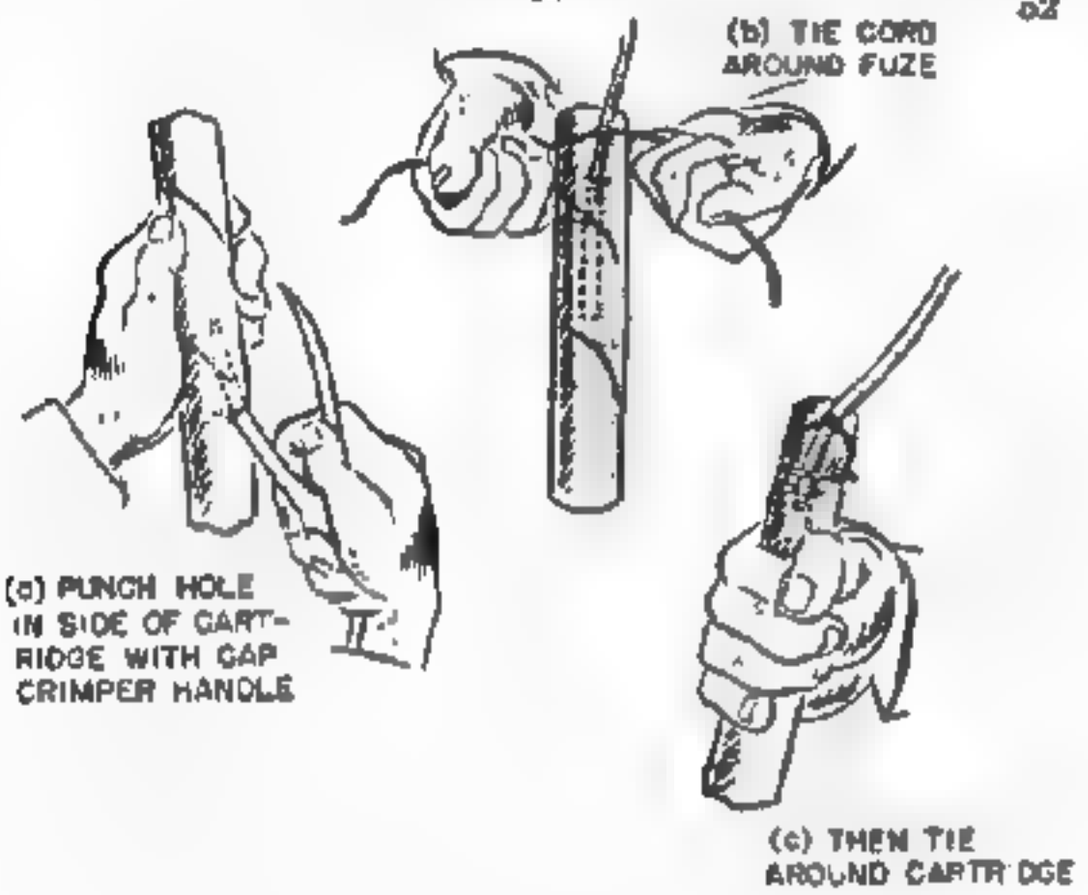


FIGURE 91.—Primer made with nonelectric cap in side of dynamite stick

FIGURE 92.—Primer made with electric cap and dynamite stick.

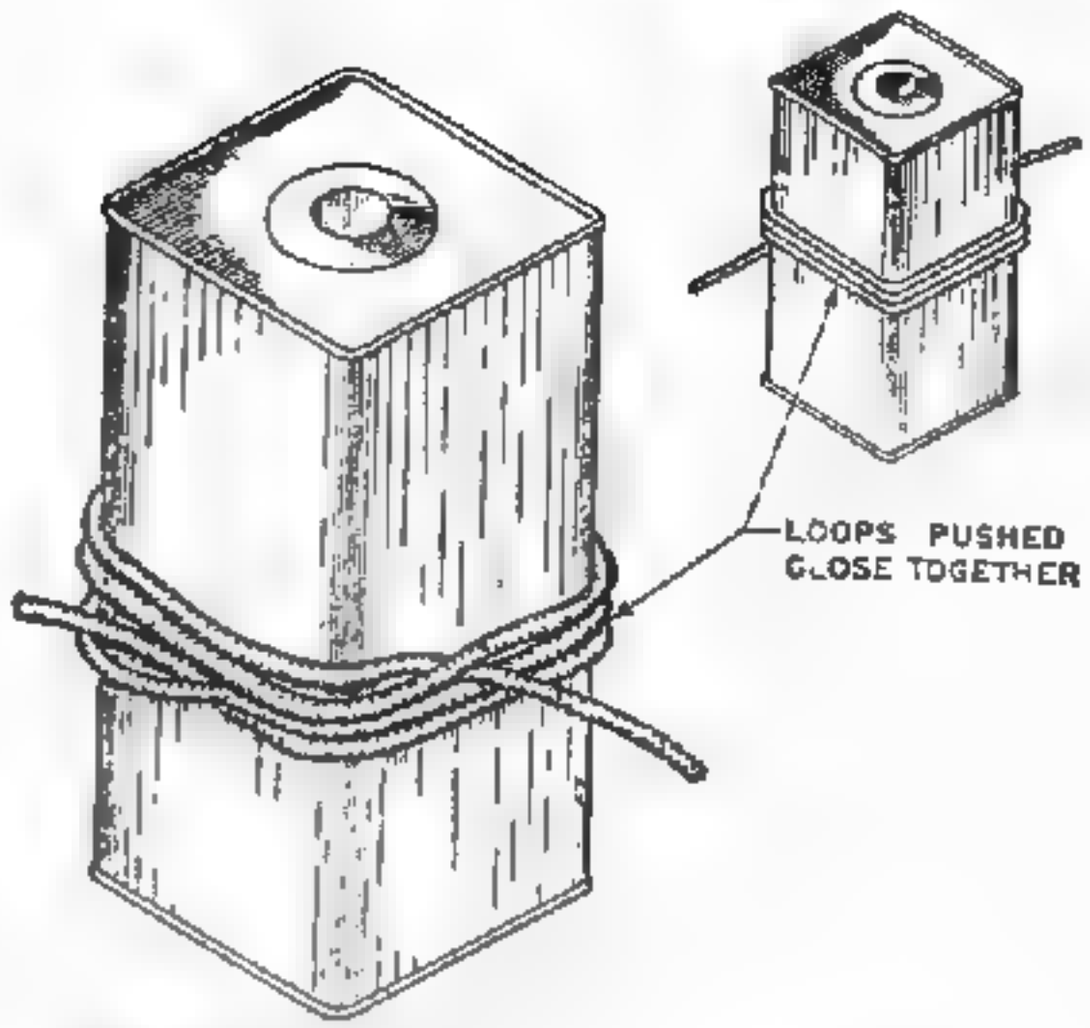
d. Time-fuse connections.—Figure 99 shows how to splice two pieces of time fuse. Make sure the powder train is continuous.

e. Improvising fuse lighter.—To make a fuse lighter when the standard lighter is unavailable, slit the fuse and insert

97 52–53

the head of a match. Keep the match head in contact with the powder train, but allow a bit of the head to protrude. The abrasive side of a match box rubbed against the match will ignite the fuze (fig. 100).

■ 53. ELECTRIC CONNECTIONS.—*a.* Cap wires are insulated by a coating of varnish on the wires and fabric cover. Figures



1. Make one-half of clove hitch.
2. Take one complete turn around block.
3. Make second half of clove hitch
4. Pull cord *tight*, pushing strands together.
5. Cord should fit snugly against block and three complete loops around block should be in contact as much as possible

FIGURE 93.—Fastening detonating cord to TNT block.

101 and 102 show how to make splices with electric wires.

b. Testing a circuit.—(1) To test a circuit use a galvanometer. The firing wire should be tested before it is connected

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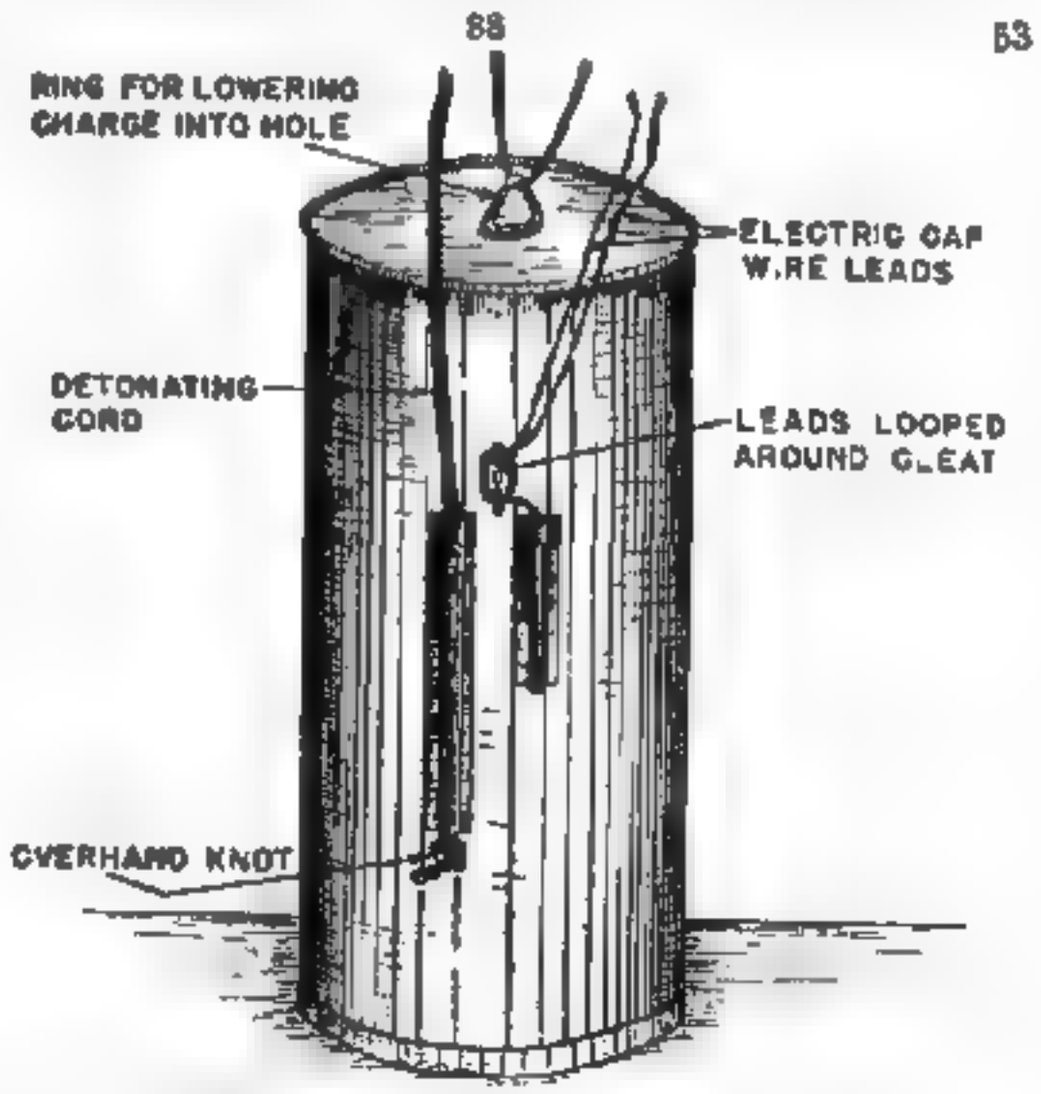

FIGURE 94.—Ammonium nitrate cratering charge with electric-cap and detonating-cord primers

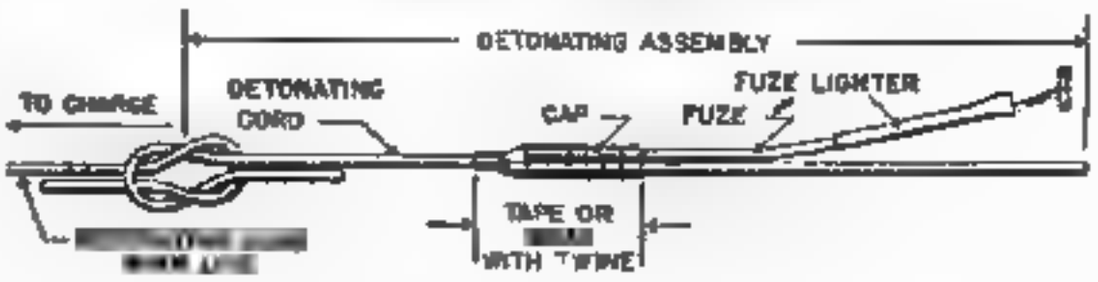

FIGURE 95.—Detonating assembly

FIGURE 96.—Attaching cap to detonating cord.

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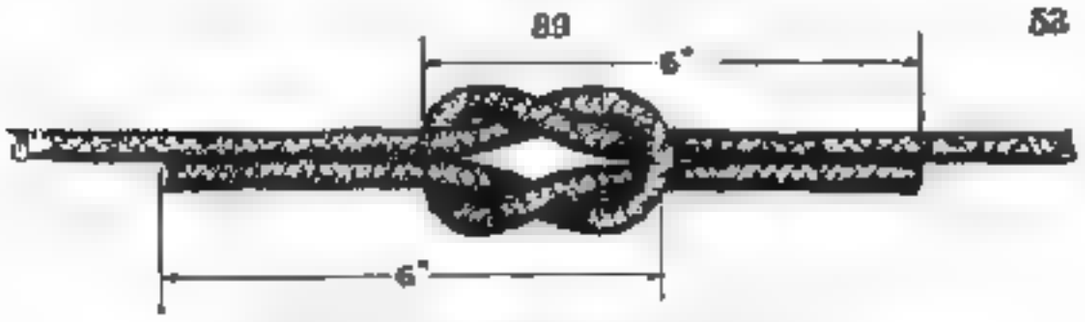

FIGURE 97.—Splicing detonating cord.

FIGURE 98.—Attaching branch line of detonating cord to main line

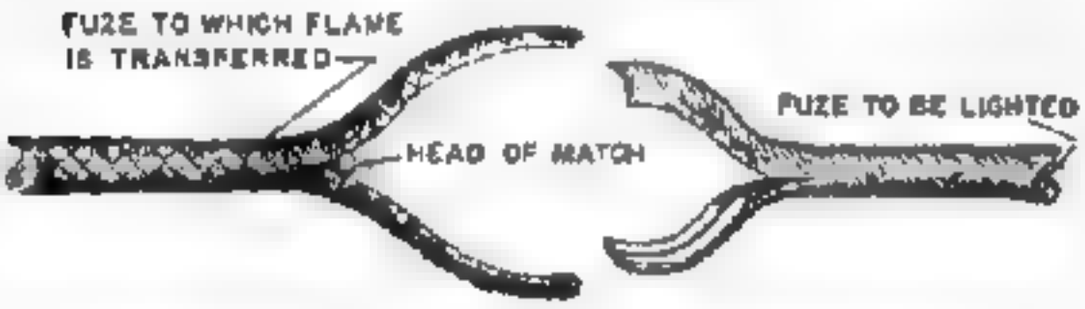

FIGURE 99.—Splicing time fuse.

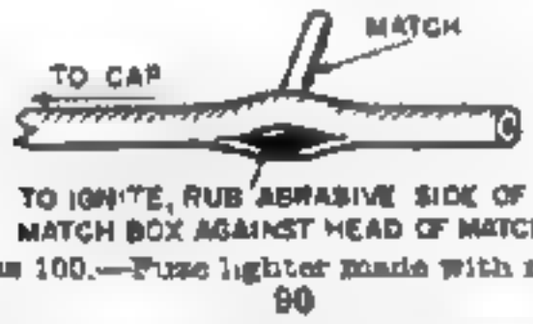

FIGURE 100.—Fuse lighter made with match.

90 53

to the cap wires to insure that it is neither shortcircuited nor broken. To do this, separate the two wires at the free end of the reel and touch the exploder ends of the wires to the galvanometer posts. The galvanometer needle should not move; if it does, it indicates a short circuit which must be repaired before the firing wire can be used. Next, twist the two free ends of the firing wire together. Then touch the exploder ends of the wire to the galvanometer posts.

(a)

(b)

(c)

(d)

FIGURE 101.—Correct method of splicing wires.

FIGURE 102.—Staggered joint for connecting cap wires to lead wires.

91 53–54

This should cause full-scale deflection of the needle. If it does not, it indicates a break or a point of high resistance, which must be repaired.

(2) After the firing wire has been tested (and repaired, if necessary) connect the free ends of the firing wire to the cap wires. Again touch the exploder ends of the firing wire to the galvanometer posts. If the needle moves along the scale, it indicates that the circuit is ready for firing if due care has been exercised to insure against shortcircuiting the cap wires while placing the charges. If the needle does not move, there is a break in the cap-wire circuit. If the needle moves only slightly, there is a place of high resistance, such as a bad joint, in the cap-wire circuit. If the caps are placed in parallel, each cap must be tested separately. Each series in a parallel series circuit must also be tested separately.

■ 54. PLACING CHARGES.—The officer, or noncommissioned officer, in charge of each demolition project gives definite instructions as to the sizes of charges to be used and where and how they are to be placed. Failure to use the proper amount of explosive results in failure of the demolition project, and placing a charge incorrectly may be just as disastrous. Don't try to save yourself work by using a smaller charge or by placing the charge in a location that is easier to get to than the location directed. If, for any reason, it is impossible to place the charge in the location or manner directed, report this fact to the officer or noncommissioned officer in charge. The following points will be helpful in enabling you to place charges properly to attack concrete, steel, and timber.

a. Crater.—Figure 103 illustrates how to prepare a borehole to blow a crater with TNT. The depth of the hole is determined by the officer in charge. In place of the TNT blocks, one or more ammonium nitrate cratering charges may be used.

b. Concrete.—Because of the difficulty of placing internal charges, concrete is normally attacked by external charges

92 54

calculated to blast through its entire thickness. In attacking a concrete wall, or a bridge abutment or pier, the entire amount of explosive is normally concentrated at the midpoint of the structure, if the width is not more than twice the thickness. Where the width is more than twice the thickness, two or more charges are used, each charge being large enough to shatter the thickness of the wall, and the

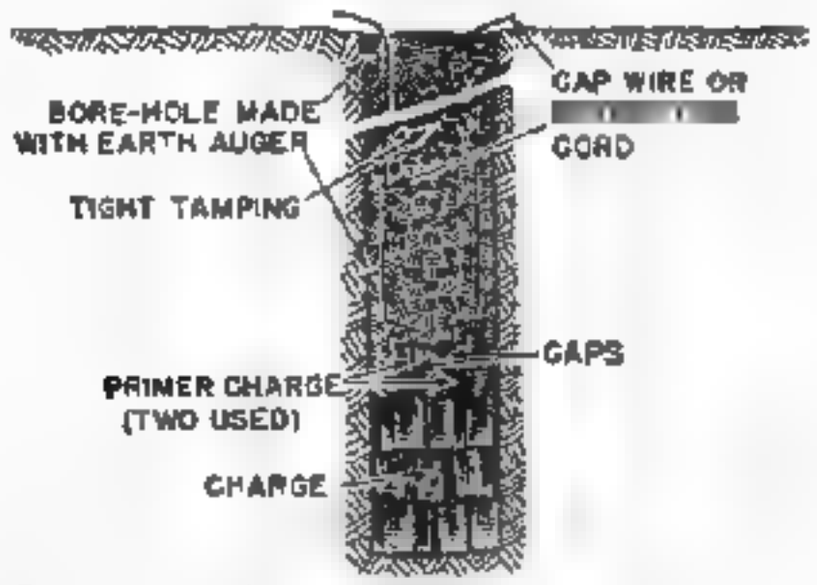

FIGURE 103.—Bore hole loaded to blow crater

distance between successive charges being not greater than twice the thickness of the structure.

c. Steel.—The effects of an explosion are very localized in steel. Only that portion of steel which is in close contact with the explosive charge is cut. A concentrated charge placed on a steel plate will simply blow a hole in the plate or dent it directly under the charge. Therefore, if it is desired to cut a steel plate, the explosive charge must be distributed over the entire line along which the cut is desired. Likewise in cutting steel I-beams, built-up girders, columns, etc., the charge must be distributed so that the entire cross section of the member will be cut. (See fig. 104.) Charges must never be placed directly opposite one another on opposite sides of a steel plate or members. When charges must be placed on opposite sides they should be 3 inches apart along the member.

d. Timber.—External charges for cutting trees, round tim-

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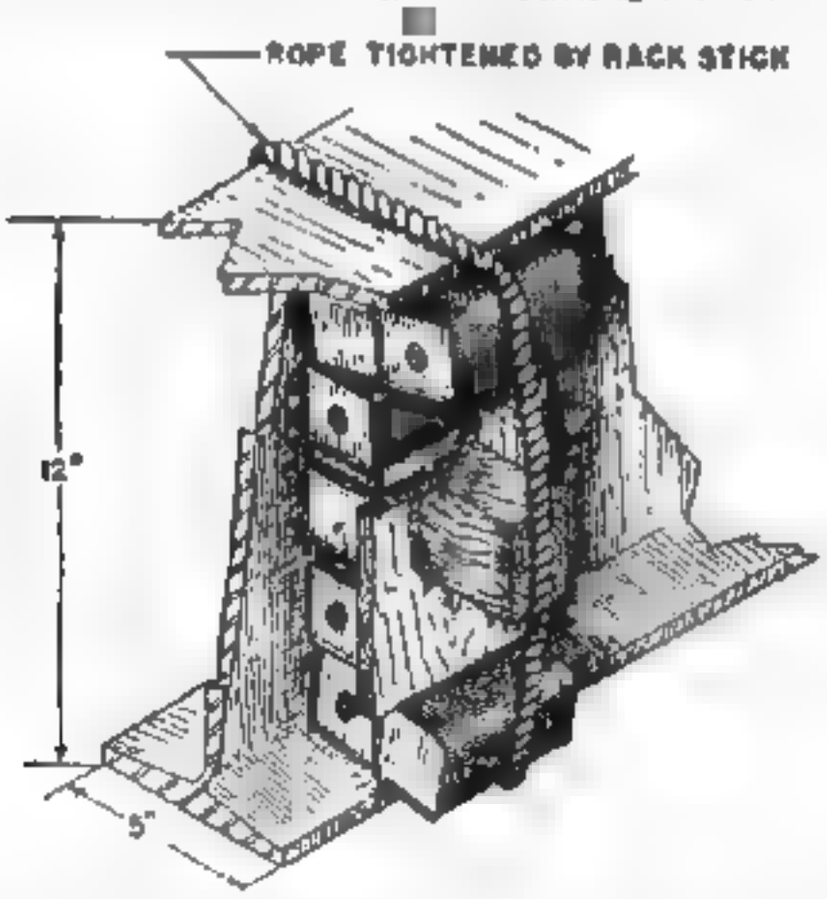
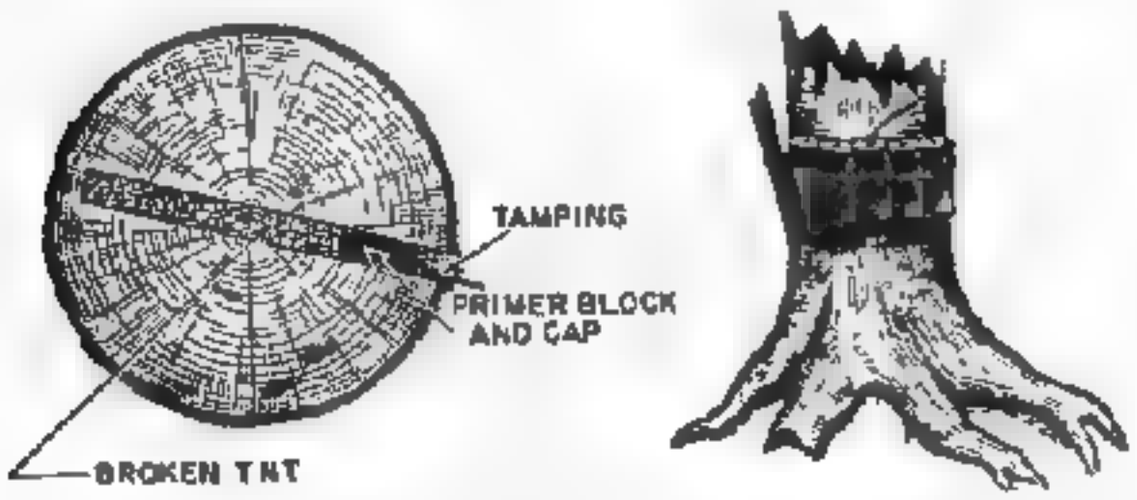


FIGURE 104.—How to blow 12-inch I-beam. Note location of TNT blocks



① Internal charge. ② External charge.

FIGURE 105.—How to blow round timber.

bers, etc., are placed around one side of the object (fig. 105). The charge should not extend more than halfway around the object being cut. External charges for cutting square timber members are placed on one face along the line of the desired cut. In the case of rectangular timbers not having

94 54-55

a square cross section, the charge is placed on one of the faces having the longer dimension. For example, to cut 10- by 12-inch timber, the charge is placed on one of the 12-inch faces. Internal charges require only about one-sixth as much explosive to cut timber as external charges. Hence, when time permits, an internal charge is used. Such a charge is placed in a bore hole in the timber, and well tamped with moist clay or mud. An underwater charge for cutting a timber pile is fastened to a board, then shoved beneath the water surface in close contact with the pile, where it is lashed or nailed in place.

■ 55. SAFETY PRECAUTIONS.—*a.* Don't forget that explosives are *always* dangerous.

b. Don't smoke while handling explosives, nor handle explosives near open lights, fires, or stoves.

c. Don't handle or keep explosives in or near places where there are large groups of people

d. Don't open cases of explosives near caps or other explosives.

e. Don't leave explosives in the open where they may be stolen, tripped over, or where animals can get at them

f. Don't leave explosives in wet or damp places; keep them locked up in a dry place.

g. Don't use frozen, chilled, or bleeding (leaking) dynamite

h. Don't try to thaw dynamite; have an expert do it with the proper equipment or get some other explosive.

i. Don't put dynamite near steam or hot water pipes or stoves.

j. Don't keep or transport caps anywhere near explosives.

k. Don't drop or tap caps or carry them in your pocket.

l. Don't take caps from box with wires or nails; use fingers only.

m. Don't leave caps out in the sunlight, or where they may be stepped on or run over. Keep them in their box until time to use them.

n. Don't pull on wires of an electric cap.

o. Don't hold caps in hand while crimping; place cap on one end of fuze and hold fuze end.

p. Don't crimp cap with anything except issue cap-crimper

95 55

q. Don't tamp with iron or steel bars or tools. Use only blunt wooden tamping stick and tamp lightly at first, then harder.

r. Don't force primer into a drill hole; make hole big enough.

s. Don't cut fuze too short; explosion may occur before safe distance can be gained.

t. Don't risk misfire by using too weak cap, employ proper cap for explosive used. You must use special issue cap to detonate TNT.

u. Don't explode charge until everyone is safely under cover or out of danger.

v. Don't connect firing wires to exploder until ready to fire charge.

w. Don't spring (enlarge) bore hole and then immediately reload; the bore hole will still be hot and may explode charge.

x. If charge fails to explode, wait at least 30 minutes before investigating it, unless an officer or experienced demolitions man directs otherwise. Explode misfired charge by means of another charge placed as close as possible to misfire. The old charge should not be disturbed

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CHAPTER 7

ENGINEERS AND TANKS

Paragraphs
SECTION I. Tank hunting 56–59
II. Antitank defense 60–61

SECTION I

TANK HUNTING

■ 56. THE ADVANTAGES ARE WITH THE HUNTER.—The big game sometimes hunted by engineers are tanks. Like any other kind of big game hunting, such as elephant hunting or lion hunting, the advantages are with the hunter; he almost always is the winner; but there is enough danger in the sport to keep the hunter on his toes. With courage and determination the engineer can use his weapons to hunt down and destroy 80,000 pounds of fighting steel.

■ 57. TANK WEAKNESSES.—Tanks have a number of weak points and any one of these may be used for its annihilation. Here are some things to remember:

a. A tank is big—a large target.

b. A tank is run by a mechanism which is breakable.

c. A tank is armored, but there is a limit to its armor and our weapons are capable of piercing the heaviest armor.

d. Tanks can't go everywhere. They can't climb steep banks, hurdle special obstacles, ford deep streams, or go through thick forests.

e. Tanks are partly blind. They can't see as well as you can.

f. They can't go over a mine undamaged.

g. They are run by human beings—men as vulnerable to fire, lead, steel, heat, and explosives as a man out of a tank.

h. Tanks are noisy; they can't "sneak up" on you, and they can't hear most noises.

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■ 58. ANTITANK WEAPONS.—The weapons of the engineer tank hunter are simple to use, but deadly in their effect. Some of the weapons used are—

a. Antitank gun, 37-mm (see fig. 66).—The 37-mm gun is a high-velocity weapon. Its armor-piercing ammunition penetrates all but the largest tanks. It is extremely accurate and maneuverable.

b. Antitank grenade.—Antitank grenades (M9) are fired from an M1903 rifle. These explosive charges have a short range (75 yards), but they do terrific damage to a tank. They are easily transported, and individual soldiers can destroy a tank with them.

c. Antitank rocket.—The antitank rocket is a new weapon—our Army's destructive answer to the tank. In the hands of the soldier, it is a powerful tank-destroying instrument, accurate up to 300 yards.

d. Frangible grenades ("Molotov cocktails") (see fig. 106).—These are incendiary grenades or improvised bottled inflammable liquid mixed with sawdust. A number of them thrown at the upper part of a tank and ignited will set the tank on fire.

e. Mines (fig. 107).—Antitank mines stop a tank and allow antitank fire to be brought upon it.

■ 59. THE HUNT.—Tank hunting follows a simple pattern, varied according to whether it is day or night.

a. Daytime hunt.—The daytime technique consists of setting a trap in a tank defile. A tank defile is a route which forces a tank to adhere to a certain path; for example, a road cut into a hill and surrounded by steep cliffs, or a road passing through an otherwise impassable bog. By means of mines the tank is confined in a limited space, and the hunters destroy it with their weapons. Smoke is used to conceal the activity of the hunters once the tank is trapped. (See fig. 106.)

b. Nighttime hunt.—At night tank crews rest themselves and their tanks. The usual procedure is for the crews to get out of the tanks and rest in the immediate vicinity, posting sentinels to guard against attack. By means of stealth, such tank bivouacs can be attacked successfully

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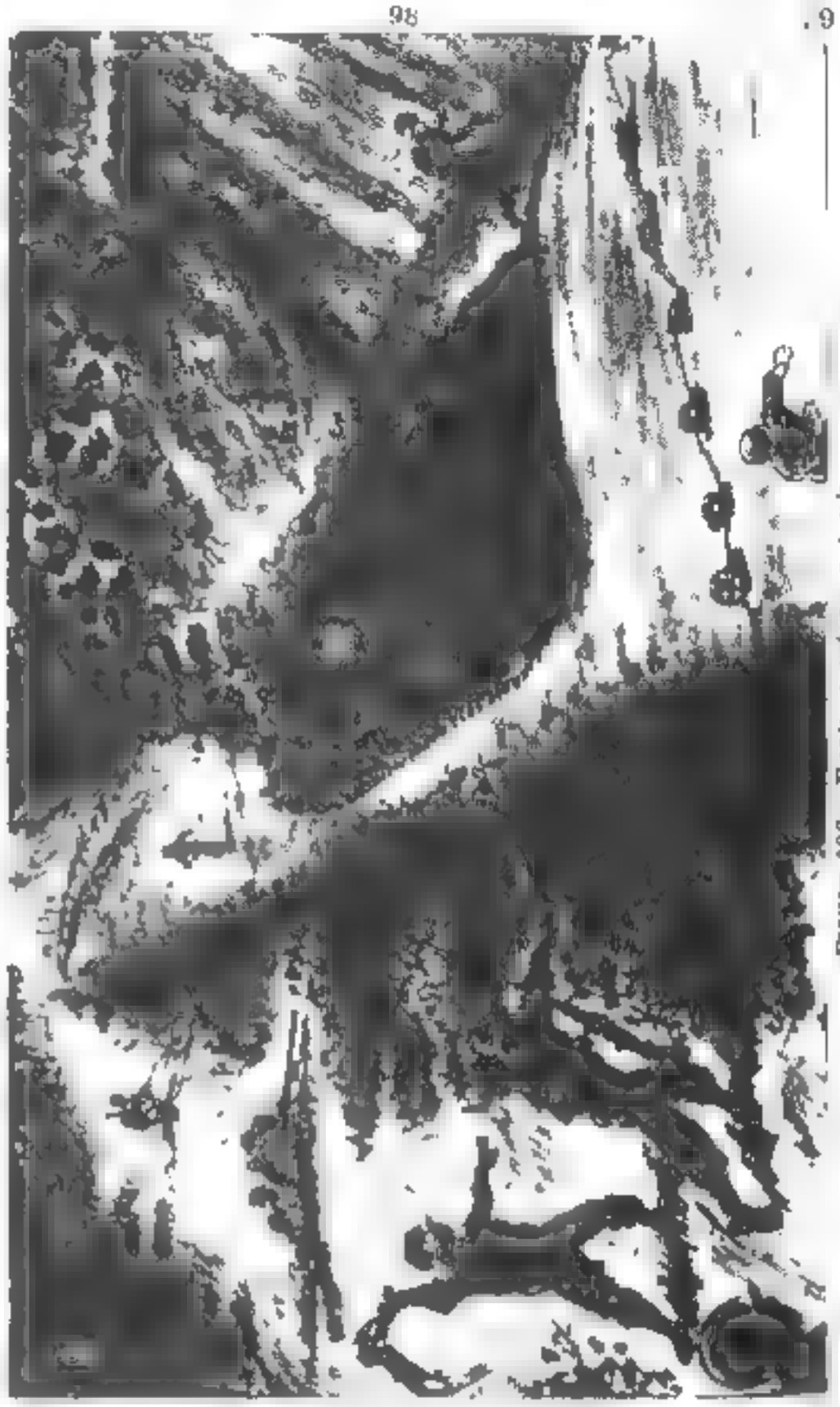


FIGURE 106. Engineers trap a tank.

99 59–60

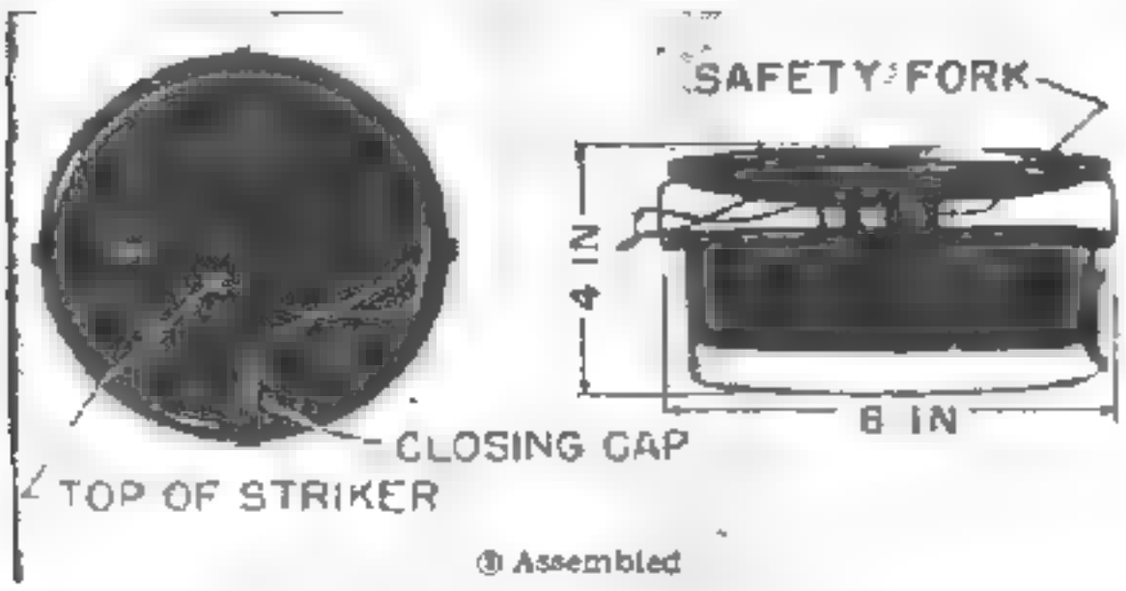
Part of the attacking party is detailed to take care of the crew members, while another party is assigned to destroy the tanks with hand-placed charges.

SECTION II

ANTITANK DEFENSE

■ 60. SECURITY.—Antitank defense is based upon two objectives: to *prevent surprise* and to *stop tanks, by means of obstacles, long enough to destroy them with antitank fire.* To accomplish the first of these objectives a constant sys-

① Disassembled.



A Assembled

FIGURE 107.—Antitank mine.

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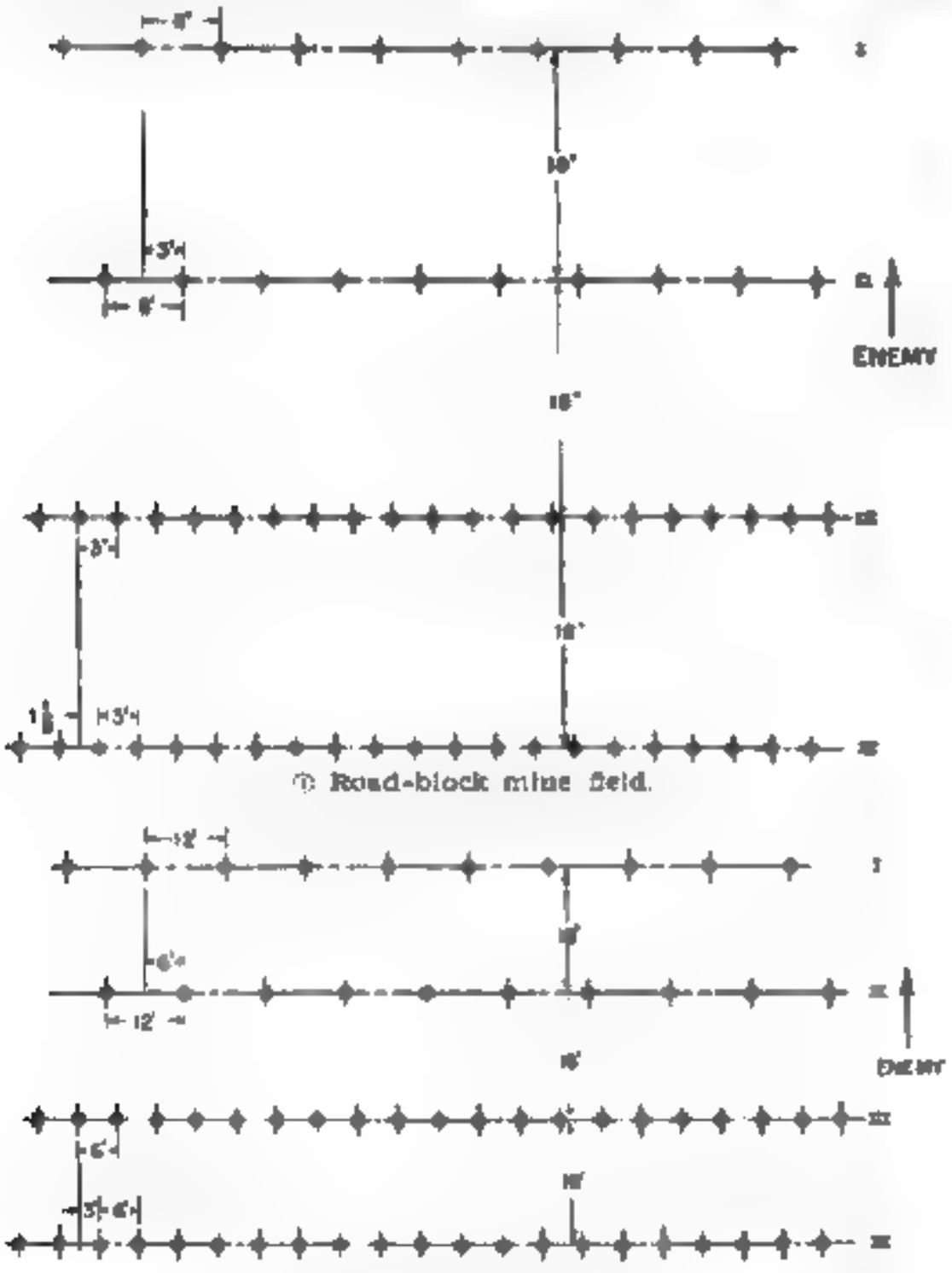
tem of sentinels is maintained; to accomplish the second a well-integrated system of obstacles, always defended by antitank and small-arms fire, is used. The small-arms fire prevents the removal of the obstacles by enemy engineers.



C Road-block mine field.

D Hasty mine field.

FIGURE 108.—Mine-field patterns.

■ 61. OBSTACLES.—*a. Mine fields.*—Mine fields are laid in definite patterns, two of which are shown in figure 108. Patterns are designed to do two things:

(1) Stop the tank before it gets through the field.

(2) Make it easier for our own engineers to remove the field later on.

The details of mine-field laying are taken up in FM 5-30.

b. Ditches.—Antitank ditches have sides steep enough to stop a tank. (See fig. 109.)

c. Posts and logs.—Post and log obstacles are effective in

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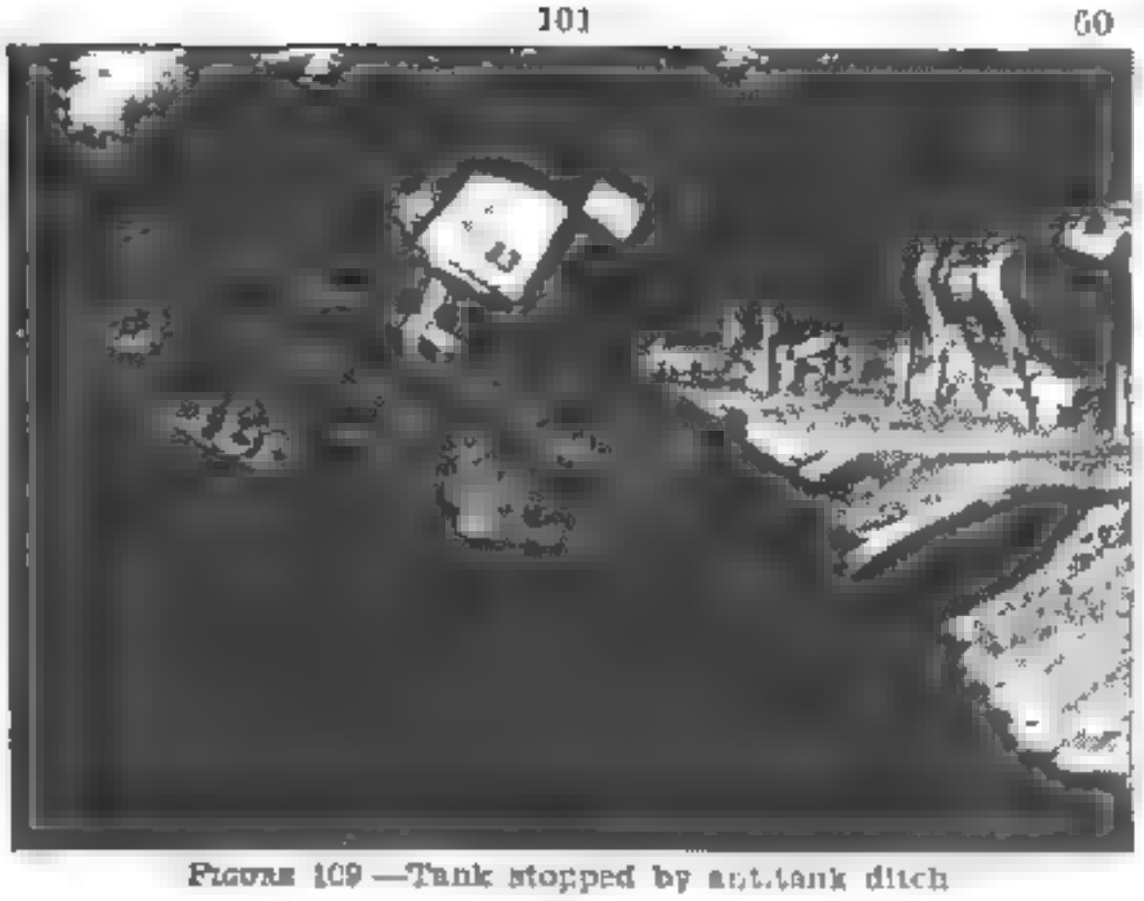

FIGURE 109.—Tank stopped by antitank ditch

FIGURE 110.—Tank stopped by log wall.

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stopping or "bellying up" a tank. (See fig. 110.)

d. Abatis.—A road block made with fallen trees can stop a tank for a time, if the trees are big enough. (See fig. 111.)

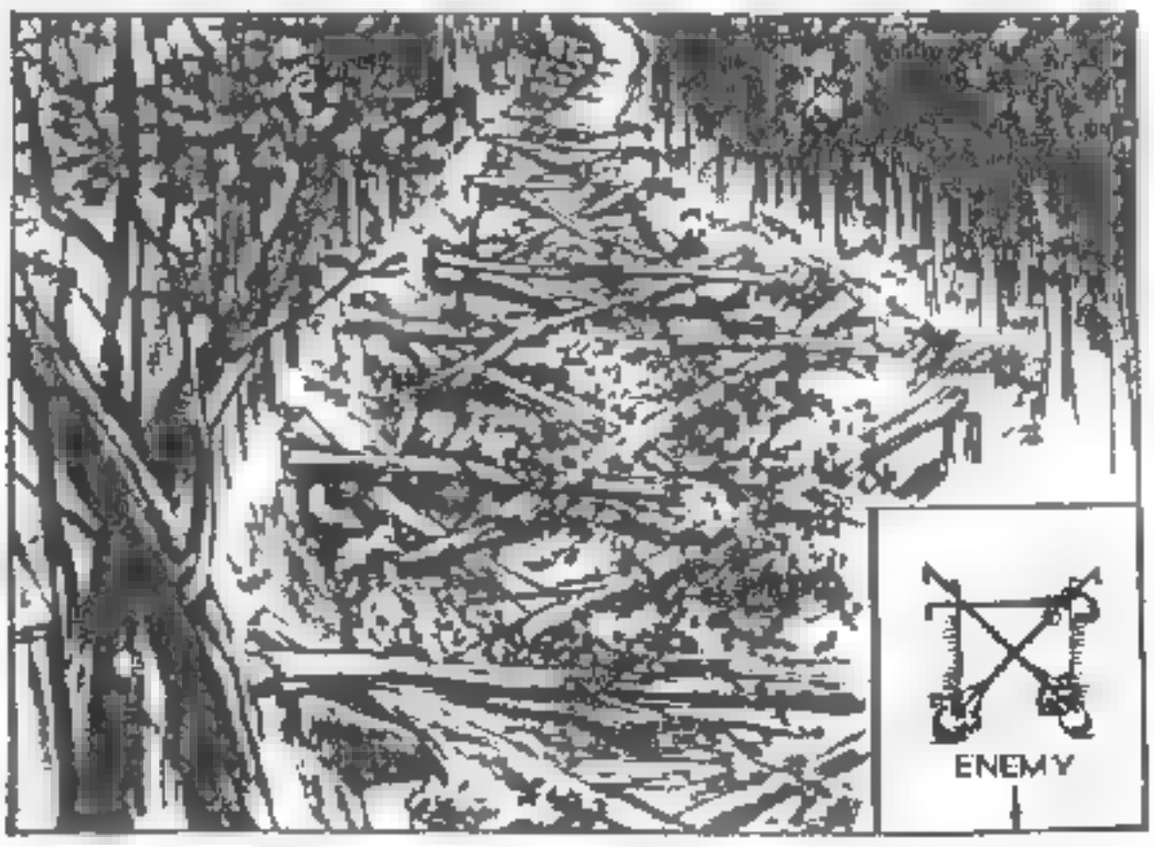

FIGURE 111.—Abatis constructed of interlaced trees in defile

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CHAPTER 8

ASSAULT OF A FORTIFIED POSITION

■ **62. The Problem —a.** A typical prepared defensive system of fortifications consists of a number of mutually supporting strong points, such as concrete emplacements called "pillboxes." The best way many of these can be destroyed is by foot troops armed with special weapons. It's a difficult combined-arms job to which engineers are often assigned. It requires aggressiveness, skill, speed, teamwork, courage, and determination. This chapter outlines procedure for a simple assault on a single fortified emplacement containing men and guns which fire from loopholes or embrasures. However, it must be remembered that pillboxes in an area are sited for mutual support; the whole problem is more complicated than this one.

b. The fortification is in a strong position. It is well aced; its walls resist bombardment; it generally has an open area around it so that its guns can cover a lot of ground. But, as the attacker, you have a number of important advantages:

(1) You are free to move around in the area, while the emplacement is stationary.

(2) The emplacement has blind spots, especially once you are close to it. It can fire only out of its loopholes.

(3) Once you get near it, the emplacement can't fire at you.

■ **63. Preparation.**—Much training is required to assault a fortified position, and the teamwork is carefully planned Each individual in the attacking force has a definite job to do at a certain time. He must accomplish his task, or the efforts of the whole force may fail.

■ **64. Organization.**—A typical assault echelon for the attack of an emplacement is composed of two platoons—an assault

104 64–66

platoon and an infantry rifle platoon. The infantry platoon attacks and neutralizes the earthen entrenchments and emplacements which are near the fortified emplacement and which cover the fortified emplacement with their fire. The assault platoon, which may include engineers, has two sections: the *assault detachment* and the support. It is this assault detachment which finally reaches and destroys the pillbox.

■ **65 Attack.**—The attack proceeds, generally, in the following steps:

a. Artillery and airplanes bombard emplacement.

b. Direct-fire weapons fire at embrasures.

c. A special detachment breaches bands of obstacles to prepare way for assault echelon.

d. Assault echelon attacks.

■ **66. Assault Platoon.**—*a.* The assault platoon works on a simple plan: one part of the assault platoon "covers" the advance of the second part until the fort is reached and the guns can be silenced by hand-placed charges. The coverin section may consist of men armed with "tommy guns," m - chine guns, pistols, grenades, and rifles, which are aimed at the gun slits in the emplacement in order to stop the fire of the defenders. The advancing group moves forward in bounds, taking advantage of shell holes and other cover. Smoke is used to cover the advance.

b. The forward element of the assault detachment has two main parts: flamethrowers, who get close to the pillbox and blind its occupants with fire and smoke (see fig. 112); and charge placers, who rush to the fortification and thrust into the weak spots of the fort (doors and embrasure openings) TNT attached to the end of long poles. (See fig 113.)

c. After one pillbox is silenced the assault group reorganizes and moves on to the next pillbox.

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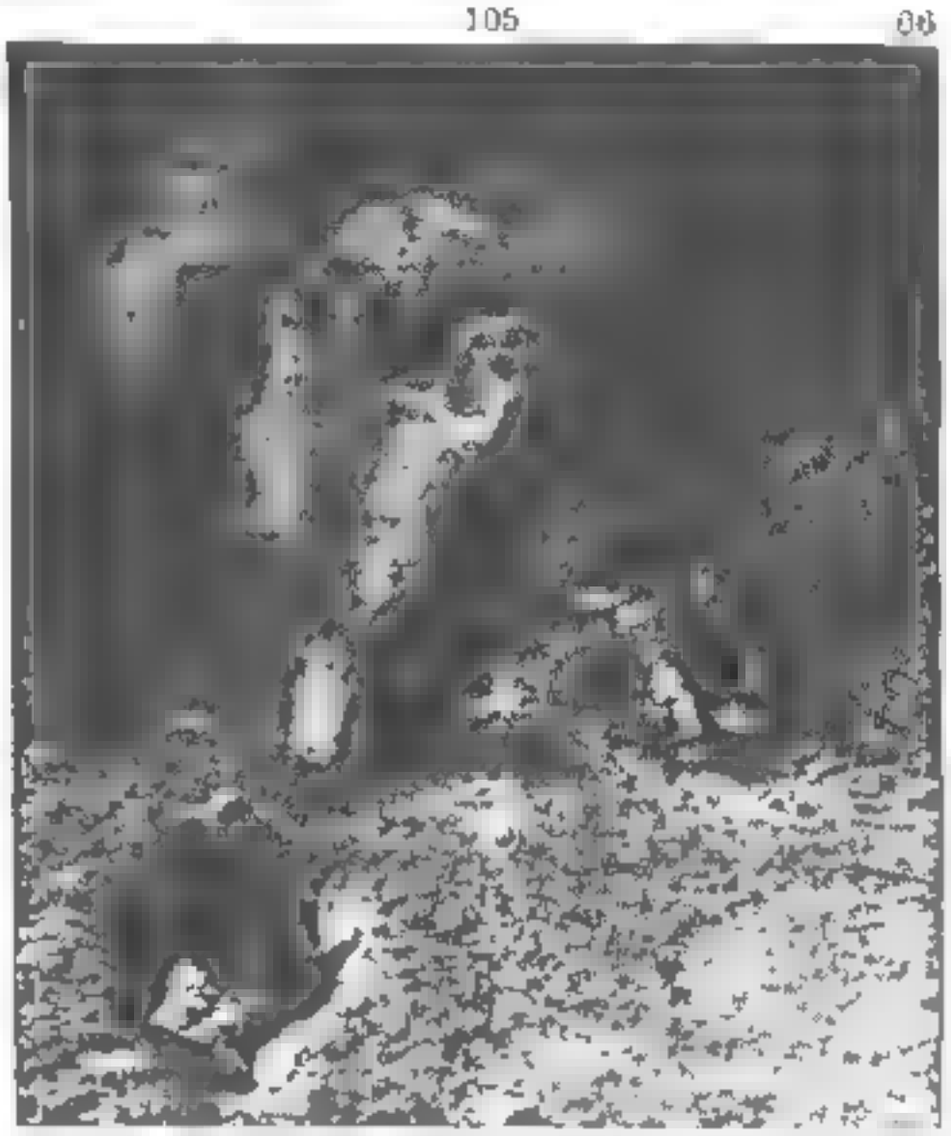

Figure 112.—Engineers assaulting a fortified emplacement.

Figure 113.—Charge-placing pole, improvised charge.

106 67–69

CHAPTER 9

BRIDGES

■ **67. General.**—An unfordable river is a difficult obstacle to an advancing army. The enemy, therefore, destroys all possible bridges in the path of advance. It is the job of engineers to build substitute bridges in the shortest possible time.

■ **68. Speed and Teamwork.**—Army engineers should be the fastest bridge builders in the world. They can build fixed and floating bridges quickly because of two things:

a. Their equipment is designed for hasty, rugged construction.

b. Their building crews are trained in teamwork and speed.

The second factor depends on the individual engineer soldier. Hundreds of feet of bridge must be built in a few hours under difficult conditions; you will be very tired sometimes you will be under enemy fire, you may be cold and wet; or hot and dry. But upon you depends so much that you must overcome all handicaps. An army may be waiting for the products of your toil. You must give all

you have in you to do the job *on time!*

■ 69. BRIDGE TERMS.—Following are some of the common terms used in bridge construction:

a. Abutment.—Shore support of a bridge.

b. Approach.—Roadway leading to the bridge.

c. Balk.—Stringers, or longitudinal load-carrying members, of floating bridge.

d. Bent.—Built-up intermediate support in bridge (see fig. 115).

e. Bracing.—Supporting members connecting adjacent bents to one another or to ground.

f. Cap.—Top horizontal bearing member of bent.

g. Chess.—Floor planks in floating bridge.

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h. End dam.—Plank at abutment of bridge, used to hold earth in place behind abutment. (See fig. 114.)

i. Footing.—Piece of wood used beneath supports to give added bearing surface on ground. (See fig. 114.)

j. Guard rail.—Flimsy rope or wooden fence on outer edges of bridge to guide foot troops and vehicles.

k. Holdfast.—Anchorage on shore to which bridge cables are fastened.

l. Pile.—Vertical member of bridge, driven into river bed. Several of them may be made into a pile bent.

m. Post.—Vertical member of trestle bent.

n. Siderail.—Curbing on bridge.

o. Sill.—Horizontal lower bearing member of trestle bent or other support.

p. Span.—Distance between centers of adjacent supports.

q. Stringer.—Longitudinal weight-supporting member of fixed bridge; it carries bridge floor.

r. Sway bracing.—Diagonal bracing on a single bent.

s. Tread.—Additional wearing surface of bridge, running longitudinally.

t. Trestle.—Built-up support, consisting essentially of vertical and horizontal members usually braced by diagonal members.

■ 70. FIXED BRIDGES.—The most common military fixed bridges are the simple stringer bridge, the trestle-bent bridge, the light portable steel bridge, often called H–10, and the Bailey bridge.

a. The simple stringer bridge is usually short. It consists of three elementary parts: two abutments, a single span of stringers, and a floor. Two types of abutments are used, one for use with soft approach roadways, the other for use with firm roadways. (See fig. 114.) Every engineer soldier should know how to construct a simple stringer bridge. Trestle bridges are merely a succession of simple spans in which the trestles take the place of abutments. Timber stringers are seldom used in spans of over 15 feet or steel stringers in spans of over 25 feet.

b. The *trestle-bent bridge* consists of two or more stringer spans. The supports between the abutments are trestle bents. (See fig. 115.)

108 70

c. The *light portable steel bridge* (H–10) (figs. 116 and 117) consists of two trusses (assembled by manpower, in lengths up to 72 feet) supporting a one-track timber deck. The 12-foot girder sections are carried in trucks and bolted together to build the bridge. The deck planks are held in place by siderail clamps, which hold the siderails to the trusses.

d. The Bailey bridge is an English panel bridge built to carry heavy loads. It can carry 70 tons on spans up to 120 feet, but requires time for erection for these loads.

■ 71. FLOATING BRIDGES.—There are a number of different kinds of military floating bridges in use. They are carried

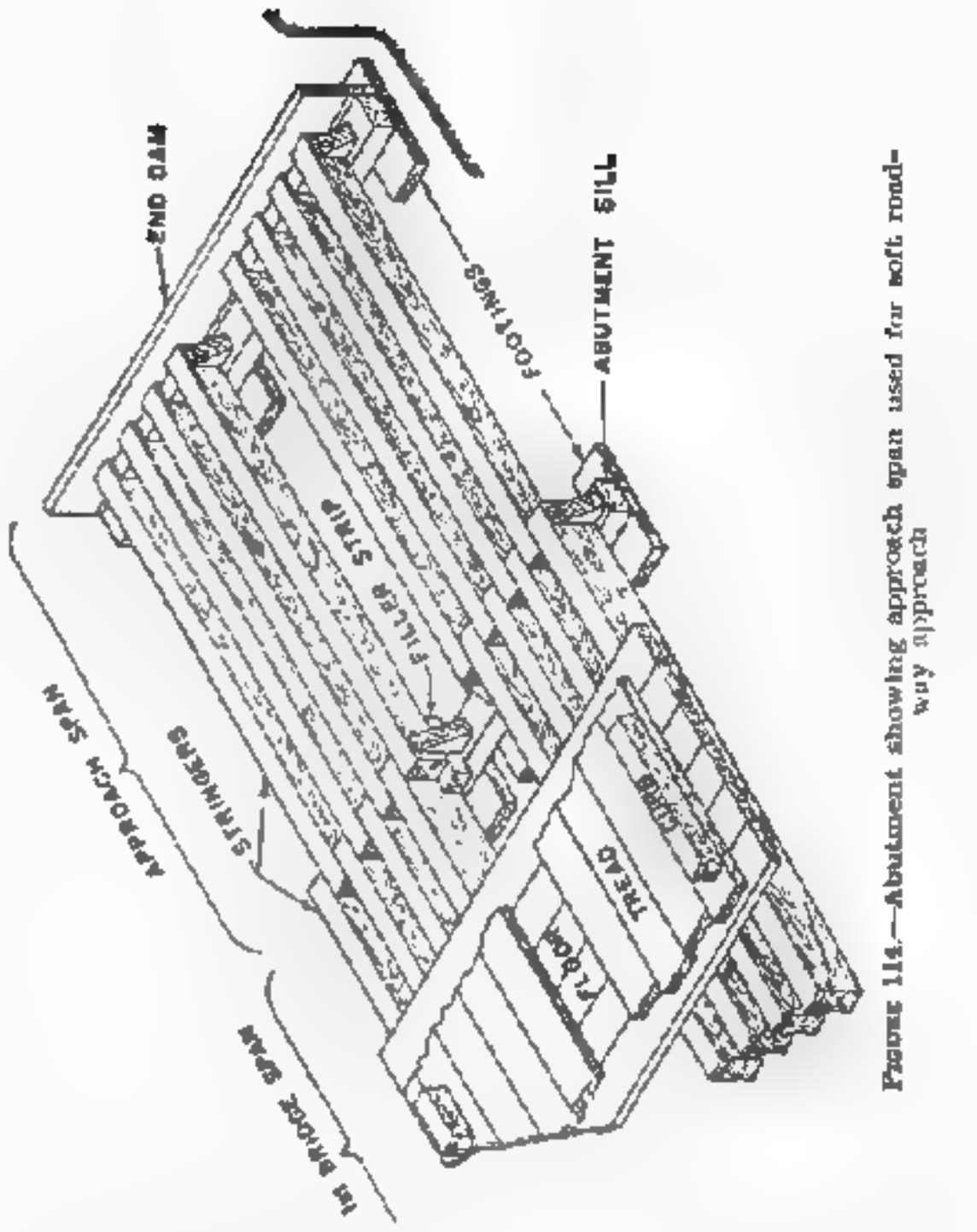

FIGURE 114.—Abutment showing approach span used for soft roadway approach.

109 70–71

by different kinds of engineer units.

a. The *footbridge* M1938 is constructed of separate rafts called "bays," each 12 feet long, consisting of a duckboard supported by two floats. (See fig. 118.)

FIGURE 115.—Standard wooden trestle-bent bridge.

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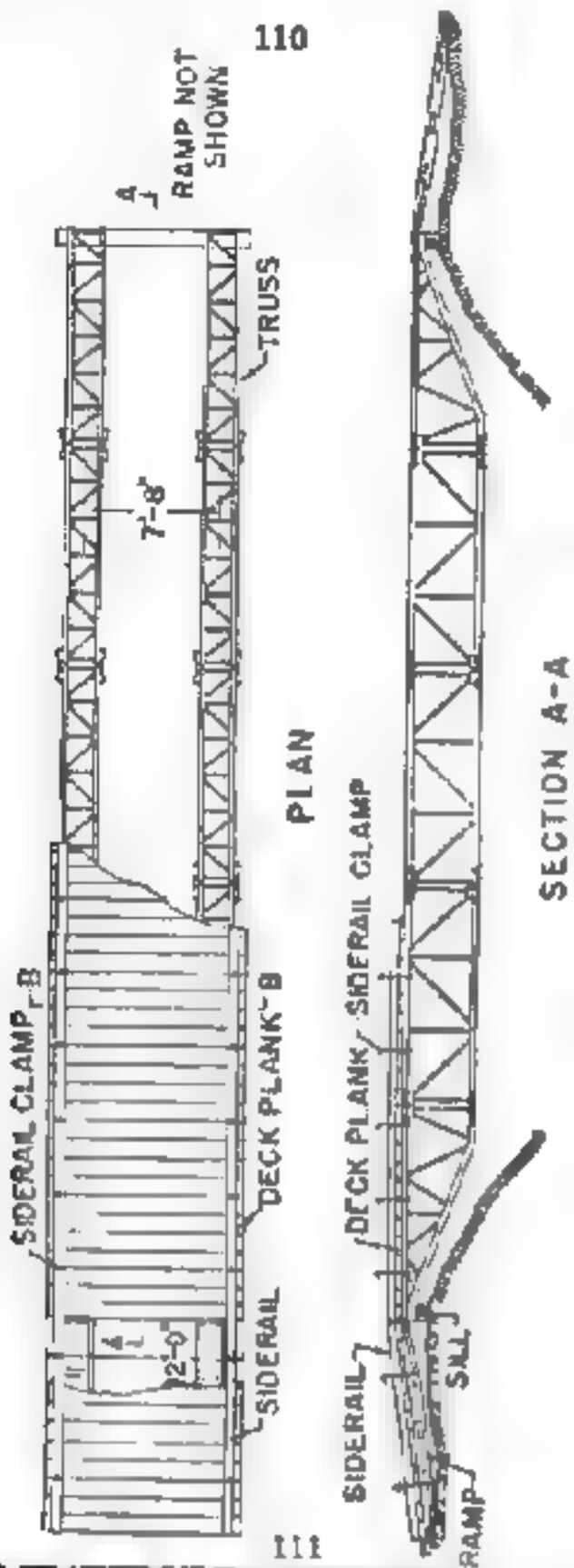

FIGURE 118.—Light portable steel bridge (H-10).

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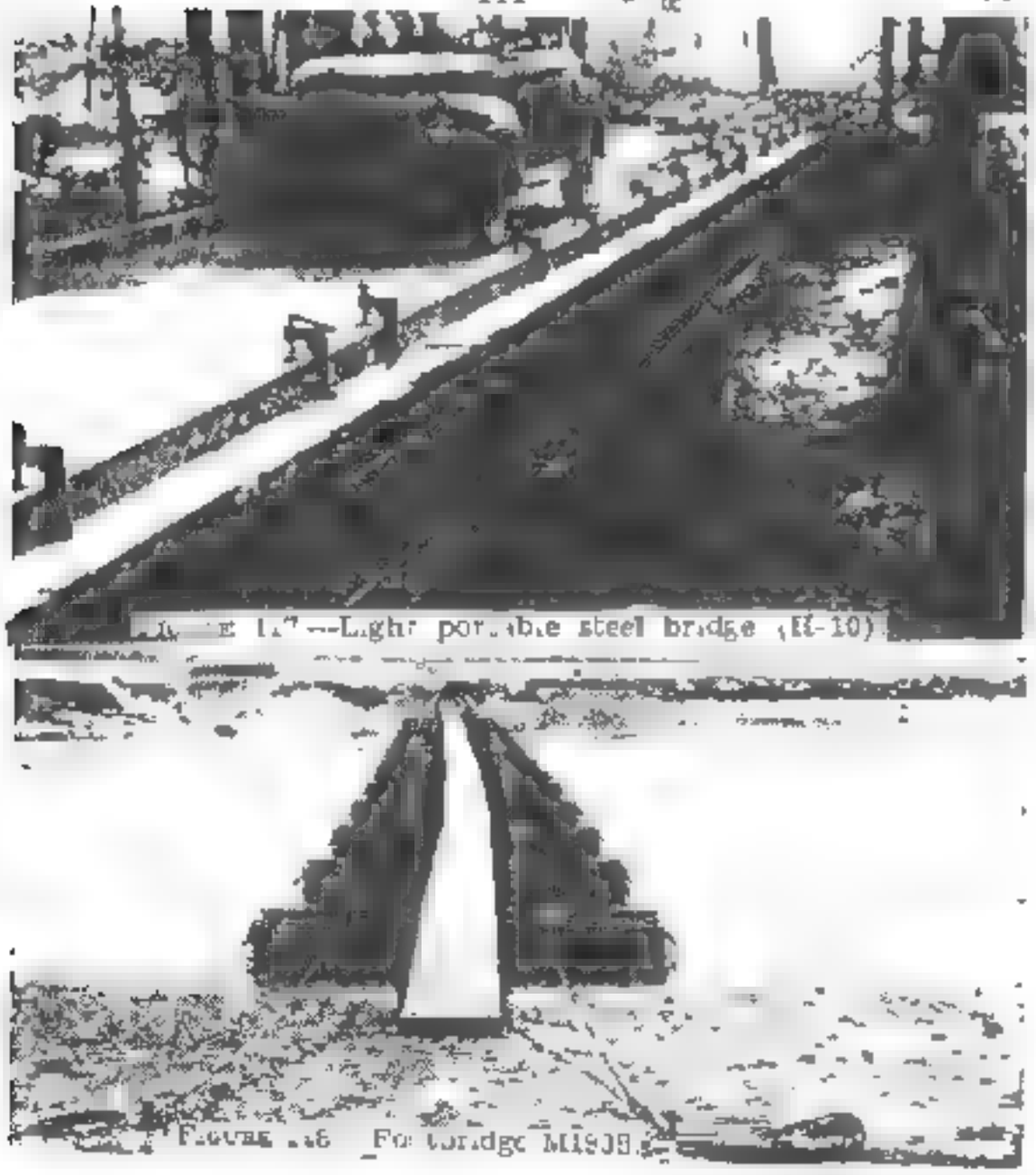

FIGURE 117.—Light portable steel bridge (H-10).

FIGURE 118.—Footbridge M1938.

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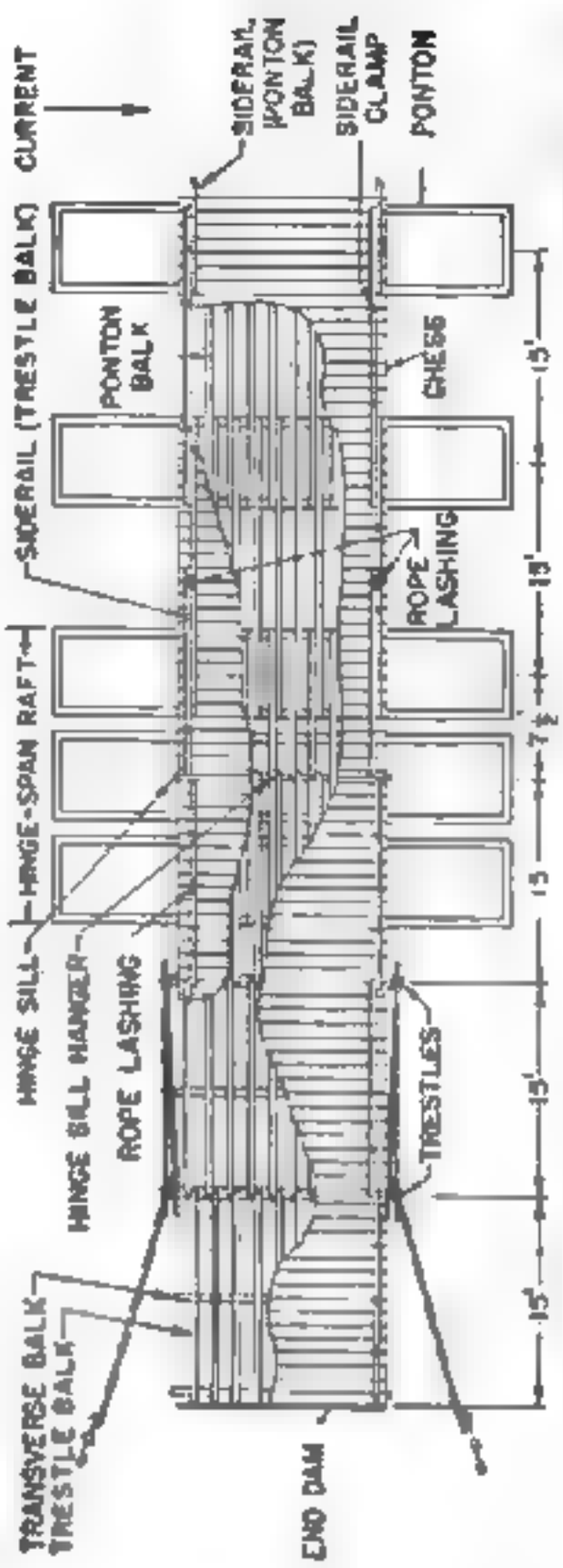

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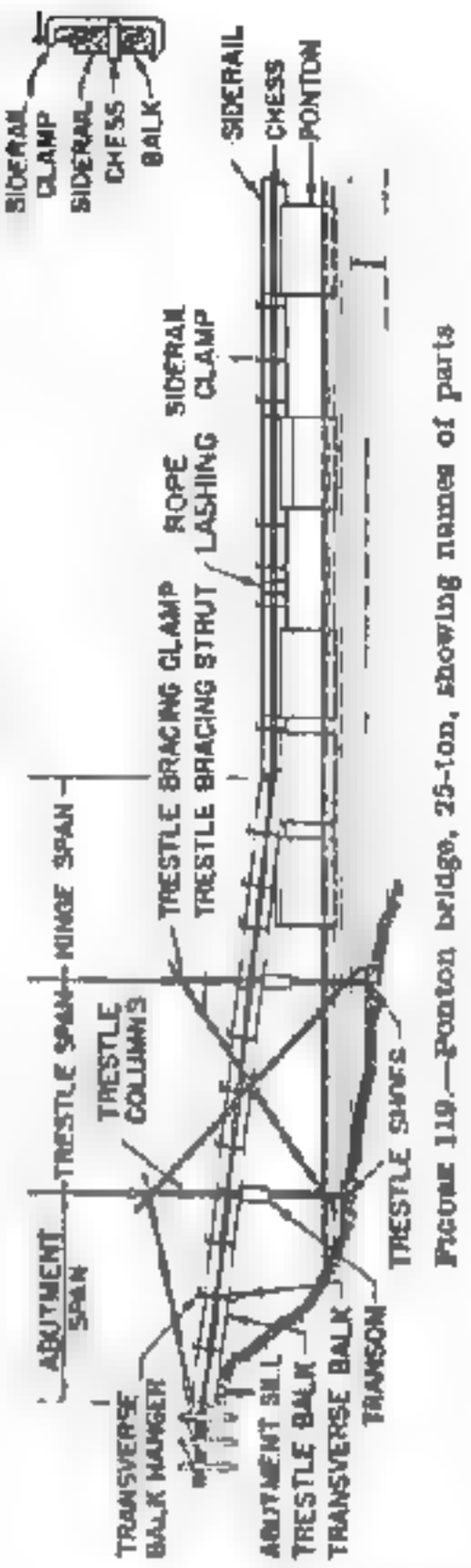

FIGURE 119.—Ponton bridge, 25-ton, showing names of parts

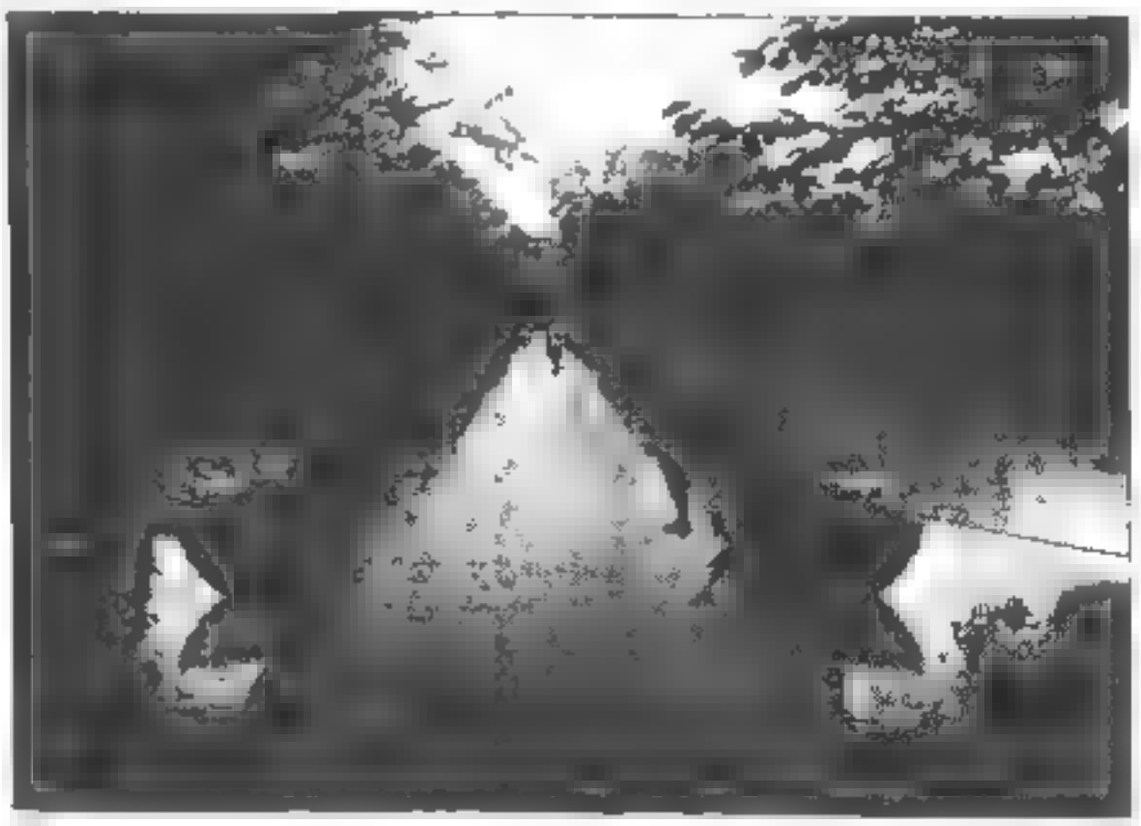

FIGURE 120.—Ponton bridge, 25-ton.

b. The *light ponton bridge* **M1938** is a floating bridge capable of carrying 10-ton traffic in one direction.

c. The *heavy ponton bridge* **M1940, 25-ton** (see figs. 119 and 120), is similar to the light ponton bridge but is much heavier and will carry 25 tons with normal construction. It

can be reinforced to carry 35 tons.

d. The *steel treadway bridge* is designed to carry medium tanks. It has steel treadways for runways, which are emplaced by means of a truck-mounted crane. It uses special rubber pontons. (See fig 121.)

e. The *pneumatic bridge* M3, made with 12-ton floats, can carry 13 tons, or, when reinforced, 18 tons. It uses regular 10-ton ponton balk and chess for the floor system. (See fig 122.)

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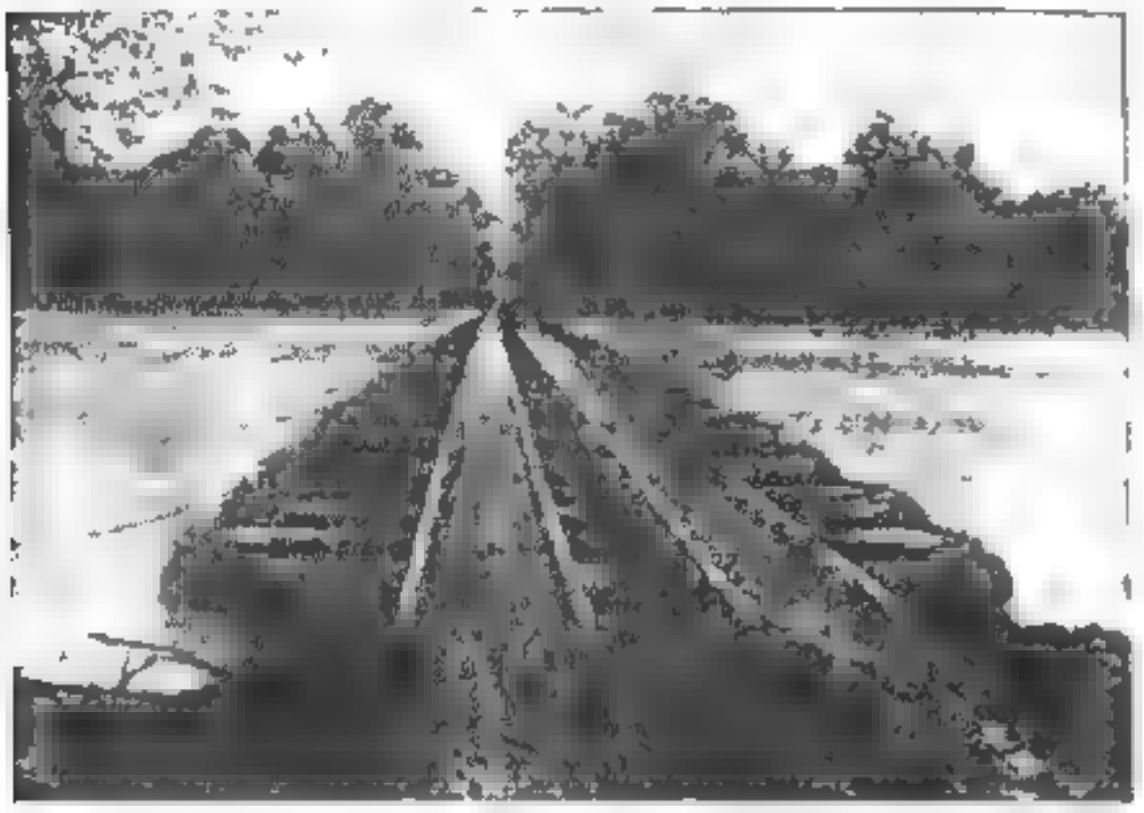

FIGURE 121.—Steel treadway bridge.

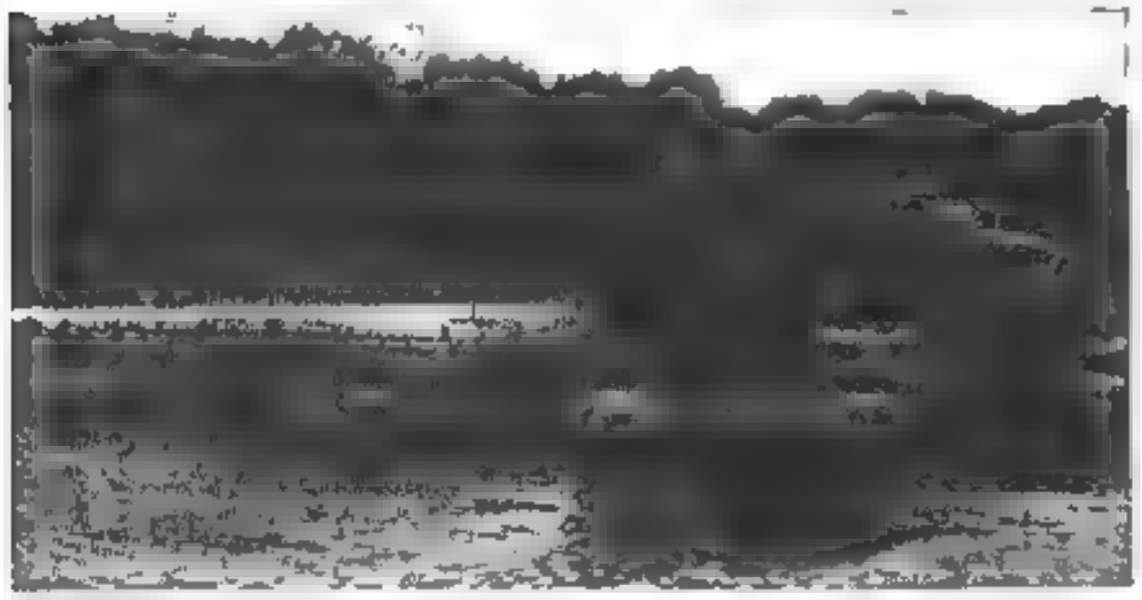

FIGURE 122.—Pneumatic bridge.

115 72–73

CHAPTER 10

BOATS AND RAFTS

■ **72. ENGINEERS IN BOATS.**—*a.* Often, before a bridge can be built, part of an army must cross a river by means of boats. It is the job of engineers to supply these boats, to manipulate and paddle them, and to carry other troops, principally infantry, across the stream. Every soldier, and especially every engineer, should be a strong swimmer.

b. Much of the crossing is done at night. Speed, silence, and coordination are demanded. It is up to you to be able to handle your boats in such a manner that the crossing may be made according to plan.

c. With proper training, handling these boats is easy. It requires only one simple rule: *Care*

■ **73. ASSAULT BOATS.**—*a. M1.*—The assault boat M1 (fig. 123 is a 200-pound flat-bottomed, plywood skiff. It carries 9 infantrymen and their equipment and an engineer crew of 2. It can be carried easily by 4 men.

b. M2.—The assault boat M2 is a 420-pound, blunt-nose scow It carries 12 infantrymen and a crew of 3 engineers (fig. 124). It is carried by 8 men.

c. Handling.—(1) The boat carriers grasp the boat by means of hand grips on the gunwales. Rifles are slung on the shoulder *away* from the boat. Care must be taken not to drag the bottom on the ground, or to bump the boat against stumps and trees. The boats are usually carried bottom-side up.

(2) The engineer in the stern commands the boat. Paddlers pass their rifles to the men in the boat who are not paddling and kneel on the knee nearest the side. The paddle is grasped just above the blade; the palm of the other hand cups the grip (end of handle). (See fig. 124.) The paddle must enter the water noiselessly at the beginning, and should be held well away from the boat during each

116 73–74

stroke to avoid thumping the side. Speed and silence are essential in making a crossing.

■ **74. PNEUMATIC BOATS.**—*a.* Engineers are equipped with a six-man pneumatic reconnaissance boat propelled with paddles (fig 125). It is inflated by means of the air compressor or by means of a hand pump.

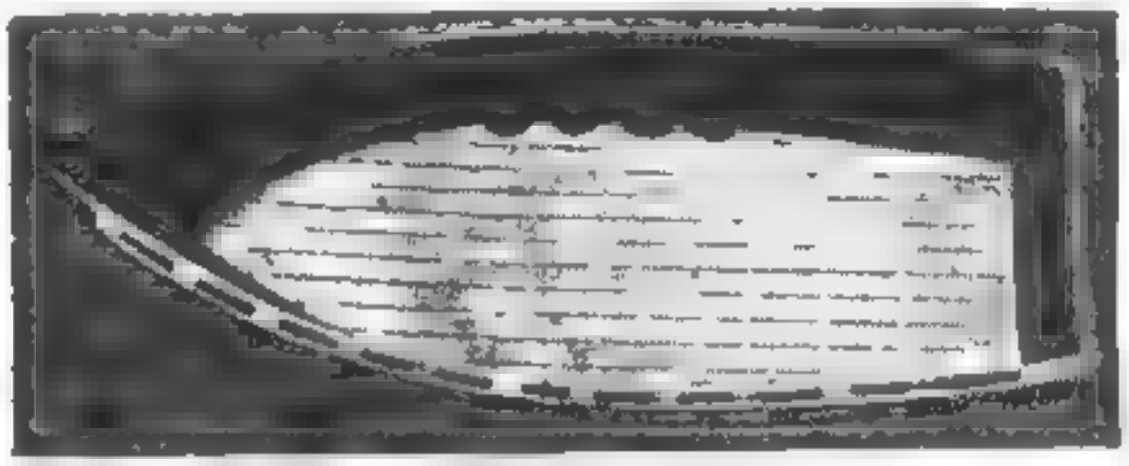

FIGURE 123.—M1 assault boat

FIGURE 124.—M2 assault boat with 8-man engineer crew and 12 infantrymen with equipment.

b. The 6-ton and the 12-ton pneumatic floats may be used as boats.

■ **75. STORM BOAT.**—The storm boat is a high-powered, flat-bottom, outboard motorboat used in the swift crossing of a wide river.

■ **76. INFANTRY SUPPORT RAFT.**—*a.* The principal raft of the engineers is the infantry support raft made out of M2 assault boats. The M2 boats were designed especially so that they may be used for this purpose.

b. The usual three-float raft is made with six M2 boats and

six plywood treadways. (Four- and five-float rafts to carry heavier loads can be made.) The sterns of the boats are fastened together in pairs, forming three floats upon which are placed the treadways. Siderails (curbing) are attached by means of siderail clamps. (See fig.s 126 and 127.)

c The raft will hold a loaded 2½-ton truck. It is propelled by means of a 22-horsepower motor, or it may be used as a ferry manipulated by ropes.

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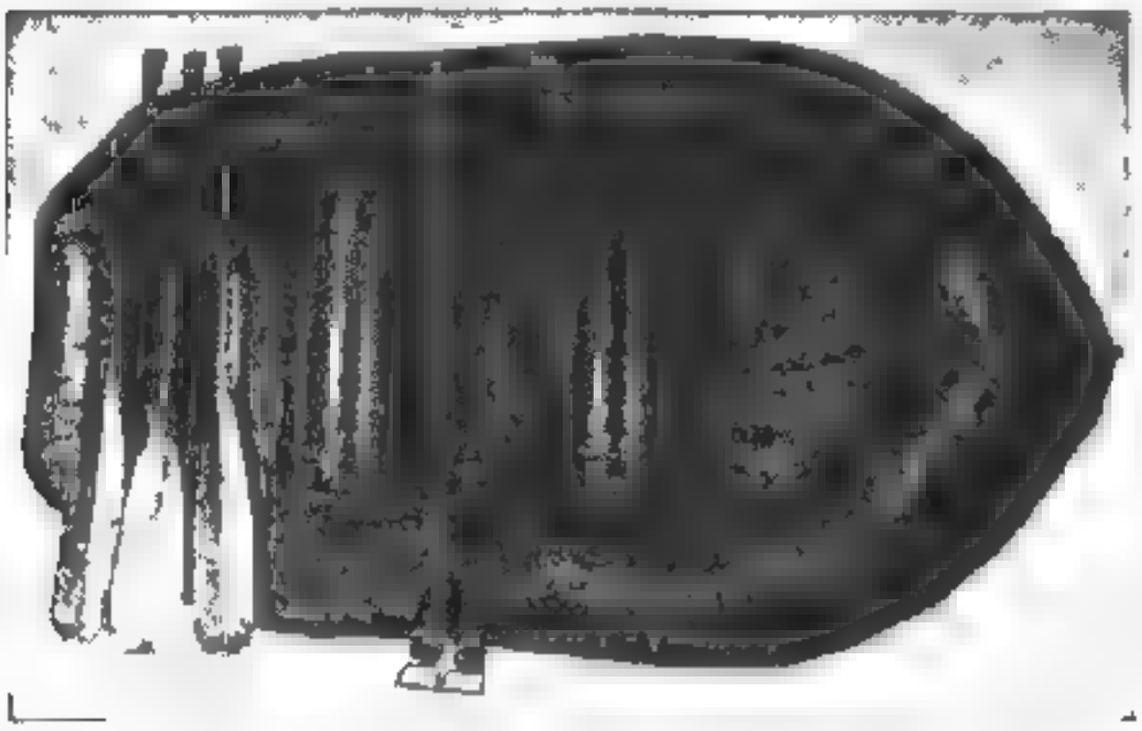
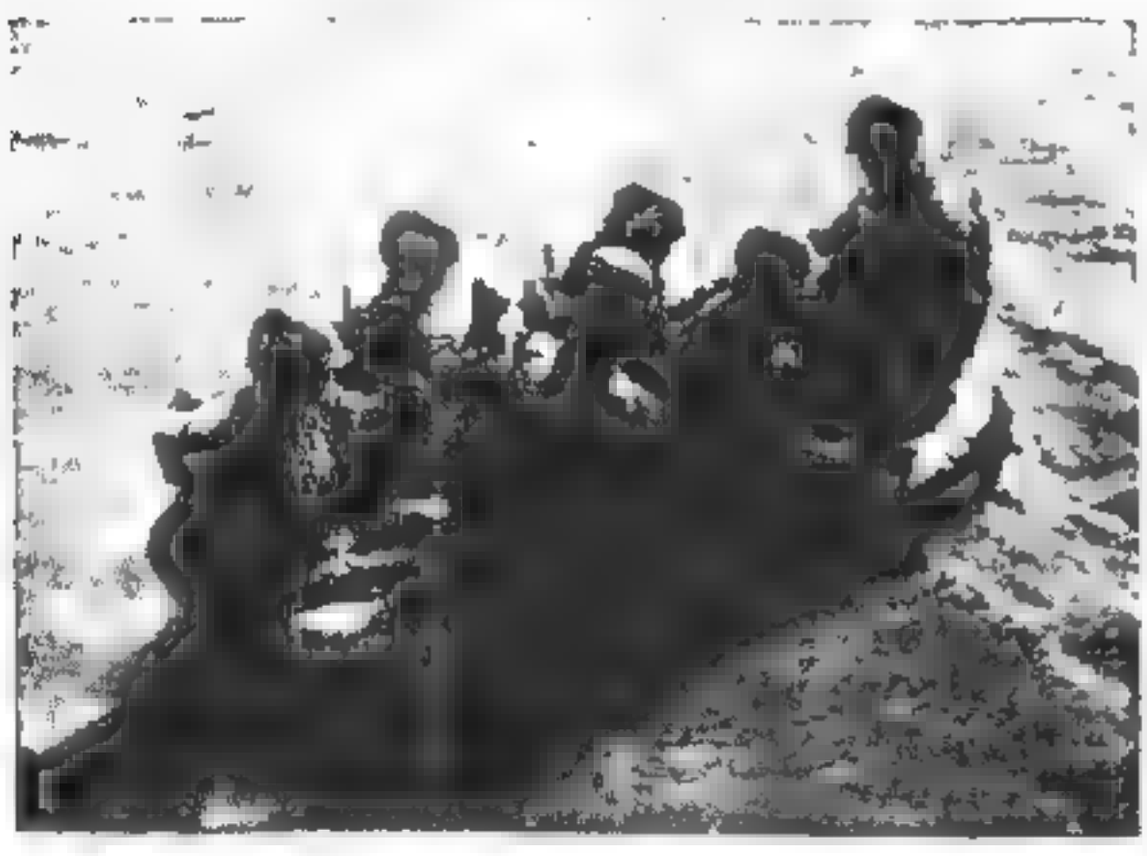


Boat with paddles and pumps



① Boat with six-man engineer crew.

FIGURE 125.—Pneumatic reconnaissance boat.

118 74-77

■ 77 PONTON RAFTS.—*a* The 10-ton annd 25-ton ponton bridge equipment may be made into rafts propelled by outboard motors.

FIGURE 126.—Infantry support raft with outboard motor attached.

FIGURE 127.—Loading the raft.

AIRDROMES 120 CHAPTER 11 87-79

■ 78. ENGINEERS AND THE FLIERS.—Engineers prepare the way for the Army Air Forces. They are builders, defenders and maintainers of airfields. Well armed and with much mechanical equipment, aviation engineers plunge into the wildest country, the most forward battle areas, and build swiftly the bases from which our aircraft fight. Once built, these bases must be defended and kept in good condition despite bombing, strafing, or artillery bombardment. The flier depends upon the engineer for this support. *You must not let him down.*

■ 79. DEFINITIONS.—All army engineers should be familiar with the general design, construction, and nomenclature of military airfields, since any general engineer troops may be required to build them. *Airfield* itself is the general term applied to any area used for landing and taking-off of aircraft. Following are some of the more common terms used in connection with airfields.

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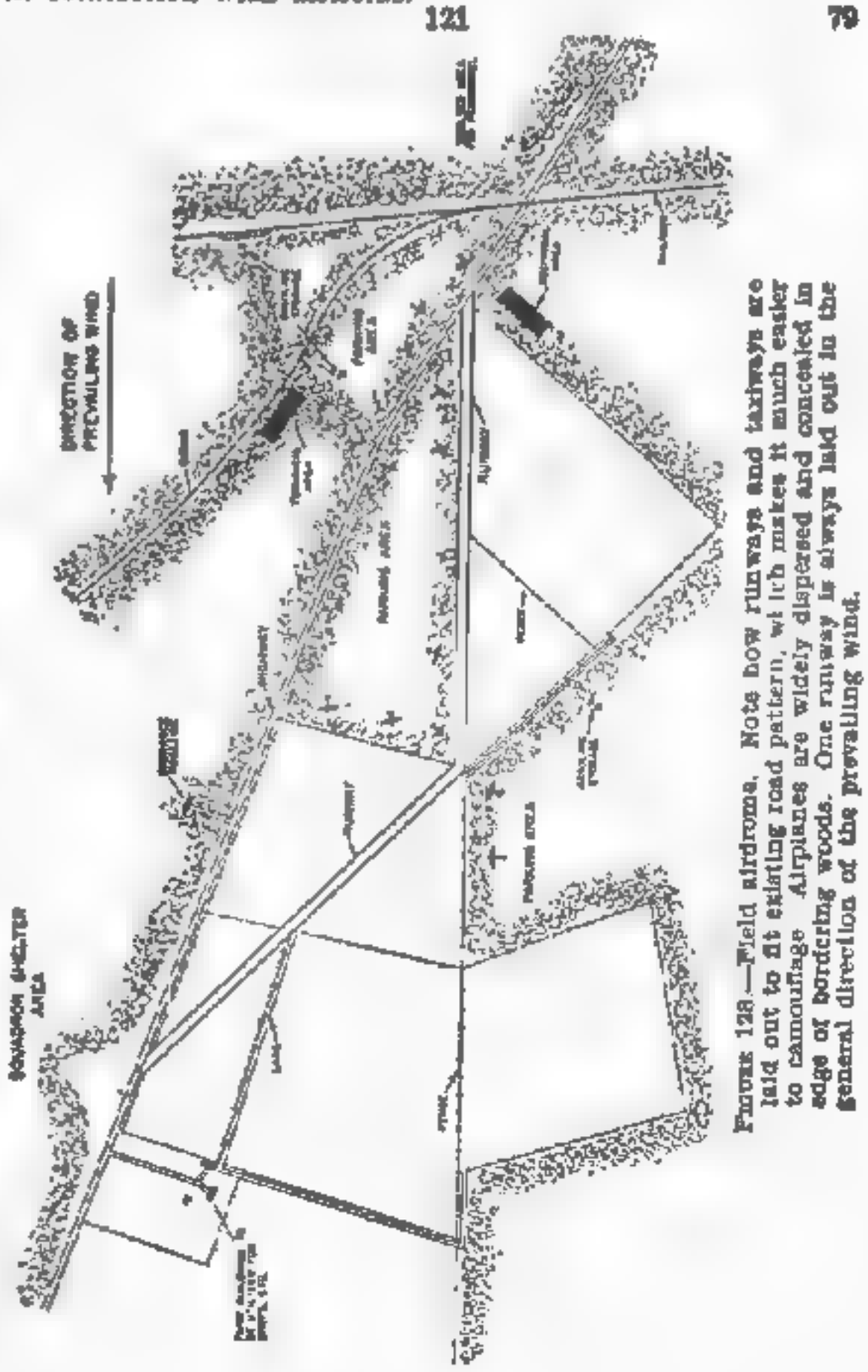
DIRECTION OF PREVAILING WIND
RUNWAY
TAXIWAY
PARKING AREA
REVETMENT
ACCESS ROAD
CONCRETE
ASPHALT
PERIMETER TRACK
DISPERSAL AREA
CONCRETE
ASPHALT
REVETMENT
CONCRETE
ASPHALT
RUNWAY
TAXIWAY
REVETMENT
DISPERSAL AREA
PERIMETER TRACK
ACCESS ROAD

a. Advanced landing field.—Temporary airfield near front, with only minimum servicing facilities.

b. Air base.—An area including a parent or *base airdrome* and one or more smaller airdromes situated at some distance from parent field. Smaller airdromes are sometimes called *auxiliary* or *satellite* fields. They depend on the base airdrome for complete repair and supply facilities.

c. Airdrome.—Landing field with facilities for shelter, supply, and repair of aircraft.

d. Alternate airdrome.—Airfield available for use of air force units, in addition to one to which they are assigned.

e. Approach zone.—Cleared area, which allows friendly aircraft to see the field at a distance and come in at a low glide.

f. Apron.—Surfaced or paved area used for parking, servicing, and maintenance of aircraft.

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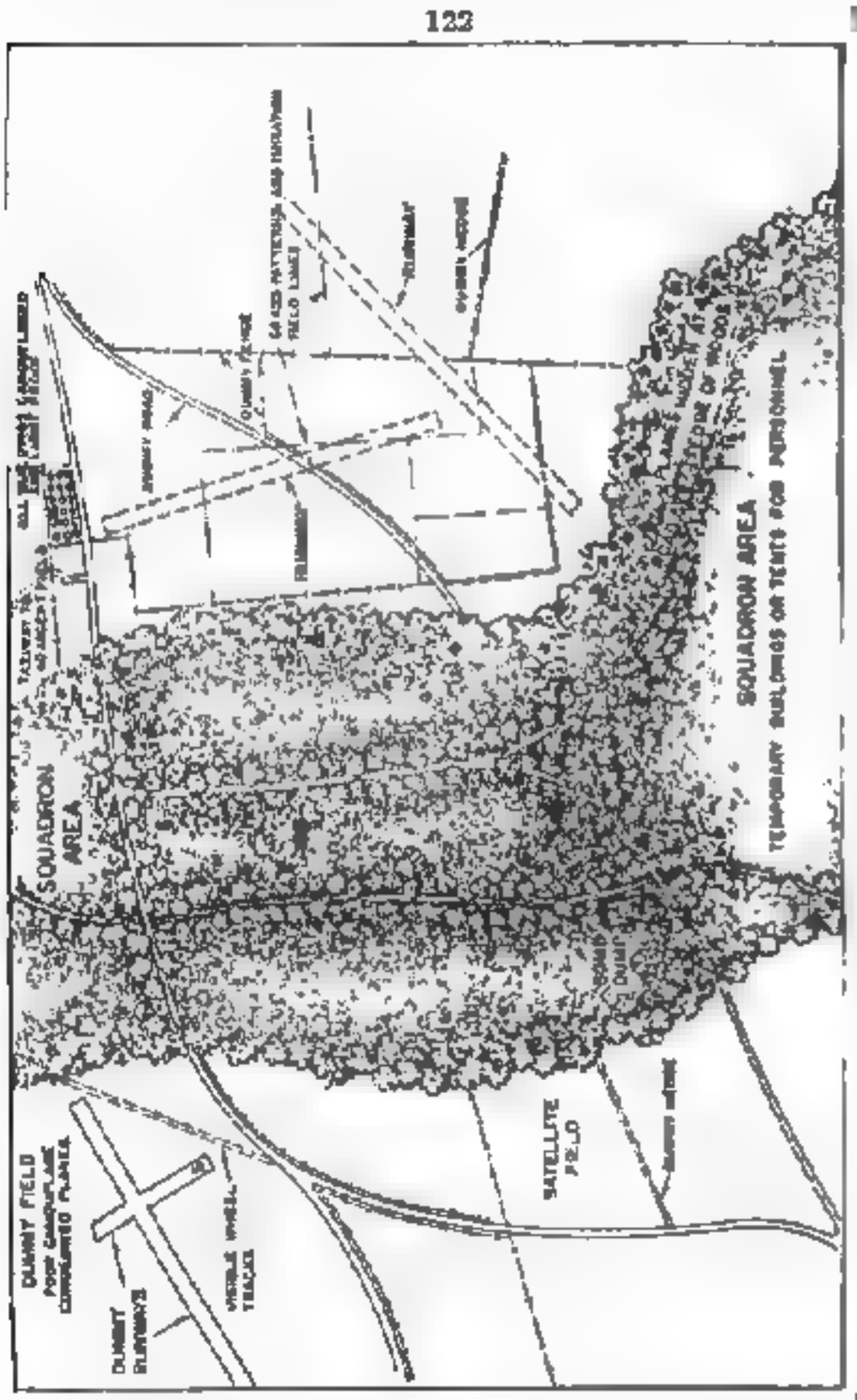

123

FIGURE 129.—Field airdrome showing extensive use of camouflage.

79–80

g. Dispersal parking area.—Area in vicinity of airdrome, used for dispersed (widely separated) parking of aircraft.

h. Dispersed airdrome.—Airdrome in which runways, technical facilities, and housing are spread out to aid concealment and lessen damage in event of a bomb hit.

i. Field airdrome.—Airfield built for wartime use only. It is built so as to satisfy minimum military requirements.

j. Hard standing.—Surfaced or paved area used for parking of an individual airplane.

k. Landing strip.—Prepared strip of land used for landing and taking-off of aircraft. It may or may not have a runway

l. Runway.—Paved or surfaced strip located in the center of a landing strip. (See figs. 130 and 131.)

m. Shoulder.—Graded area adjacent and parallel to runway.

n. Staging field.—Intermediate landing and take-off area with a minimum of servicing, supply, and shelter, for temporary occupancy of military aircraft during movement from one airdrome to another.

o. Taxiway.—Surfaced or paved way primarily intended for circulation of aircraft on and near an airfield.

■ 80. THE AIRFIELD.—The building of a military airfield is an involved and complicated construction operation. In many respects it is like building a superhighway to support very heavy wheel loads. But there are certain differences from road-building which are extremely important, and with which the aviation engineer must be fully acquainted in order to accomplish his job.

a. Construction.—An airfield must be able to take, for the most part, a heavier load than a road. Where an average heavy load for a road is a 10-ton truck, a runway may have to support an 80-ton bomber. It is clear, therefore, that airfields must be built on firm, well-drained ground, with a strong base. Figure 133 illustrates how the load of a plane is distributed through the layers making up an airfield runway.

b. Surfacing.—The surface of a runway must be smooth and even, free from pebbles or loose material that may be blown into the air and damage propellers and other

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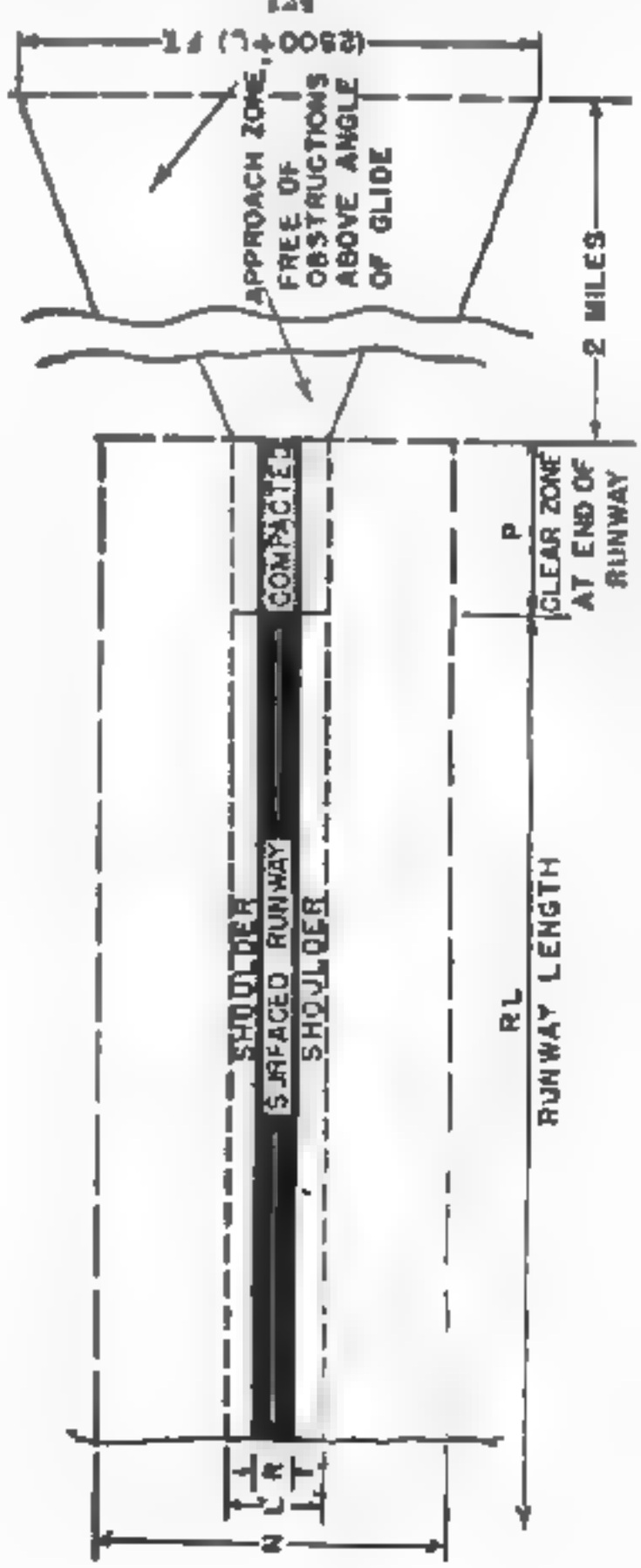

FIGURE 130.—Diagram of typical runway area.

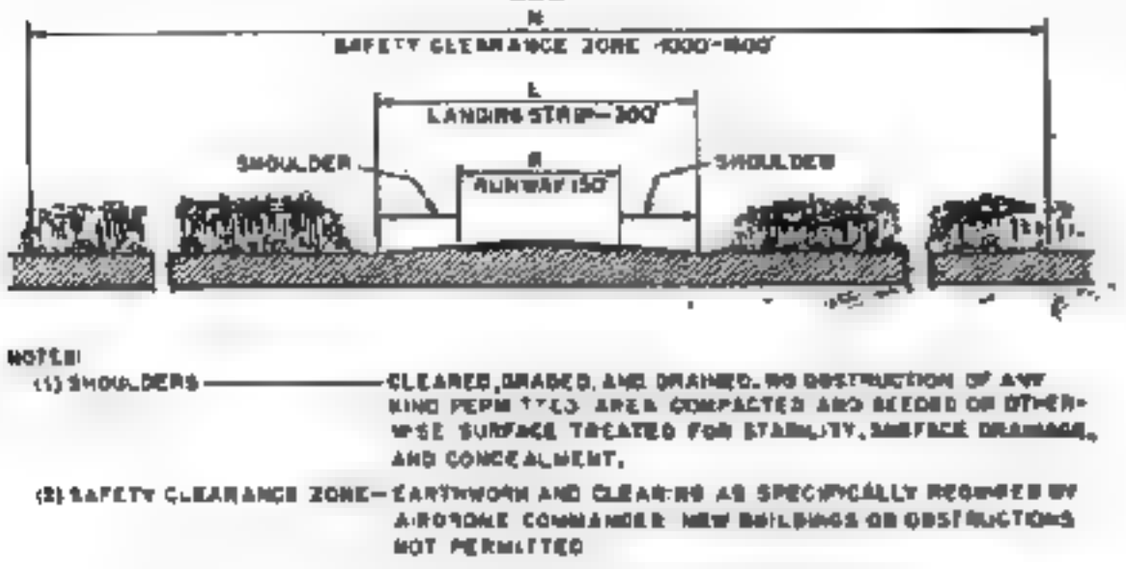

FIGURE 131.—Cross section of typical runway area.

parts of a plane. Since a plane lands at very high speeds, compared with vehicles, small rocks and other obstructions that would be unimportant in a road should not be allowed to remain on the runway.

c. Length of runway.—The faster and heavier a plane, the longer the runway must be. Therefore landing fields for bombers, fighters, and light aircraft are of different lengths.

d. Camouflage.—If we can reach enemy installations from our fields, they can likewise reach our fields. It is important that our fields be hard to find, and, if found, hard to see. Therefore an airfield is laid out to take advantage of natural concealment, and every attempt is made to camouflage both the airfields and the individual planes. (See figs. 134 and 135.) This is an important function of the Corps of Engineers.

e. Figures 128 and 129 illustrate a typical airfield and how ground features are used to help conceal it.

■ 81. STEEL RUNWAYS.—Since construction of airfields requires a great deal of time and labor, the Army has looked for ways of constructing a field quickly. For this purpose we have developed prefabricated steel landing mats of various kinds, which can be laid down quickly with a minimum of tools and equipment. It is important that every engineer know the essentials of laying down these steel runways. Figures 136 to 142, inclusive, show this kind of runway and the means of making connections among the various parts. These runways are simple to put together, but it is up to you to know how to handle the various parts for rapid construction.

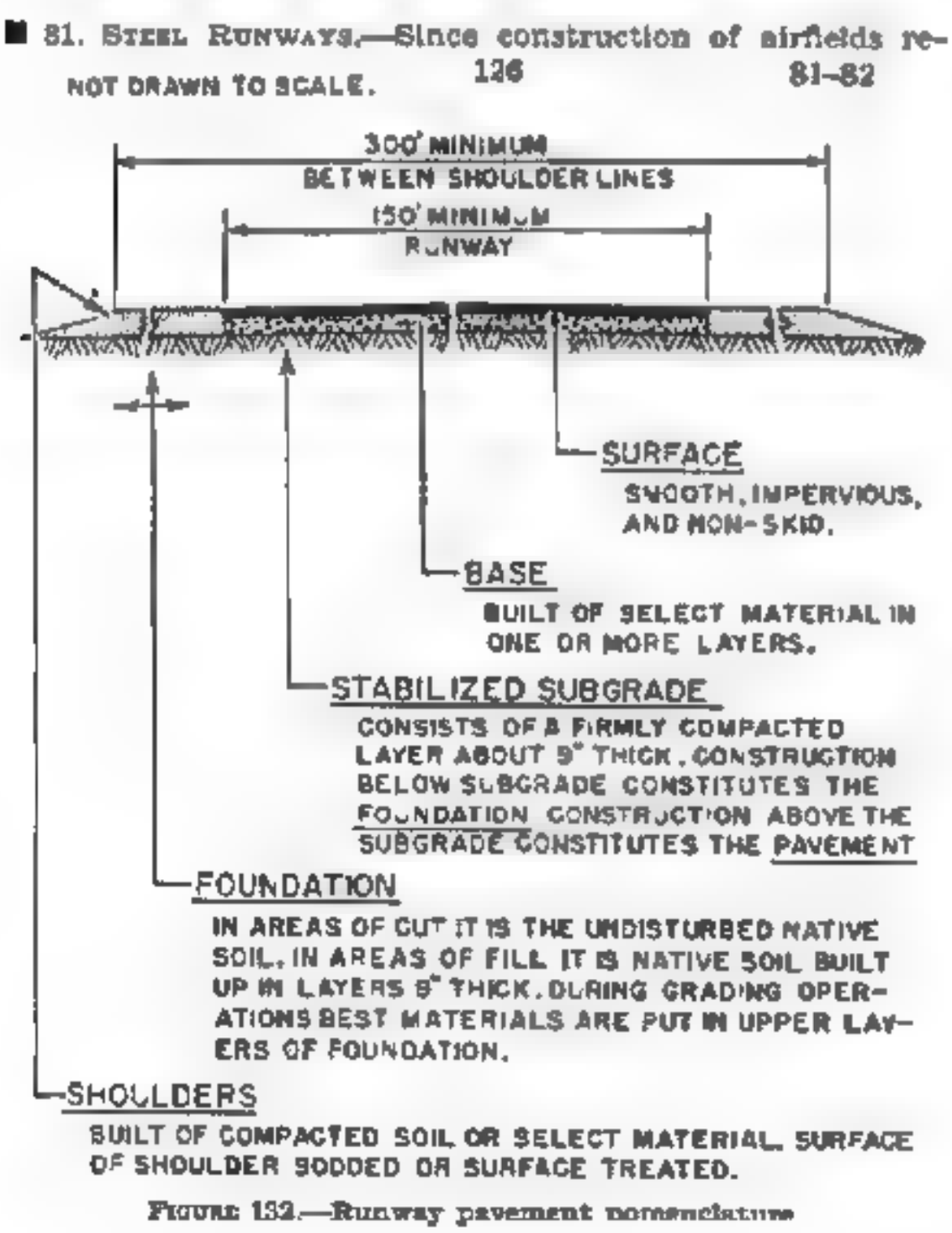

FIGURE 132.—Runway pavement nomenclature.

■ 82. THE AIRFIELD AND THE ENGINEER.—*a. Maintenance.*—Building the airfield is a big job, but the engineers' job does

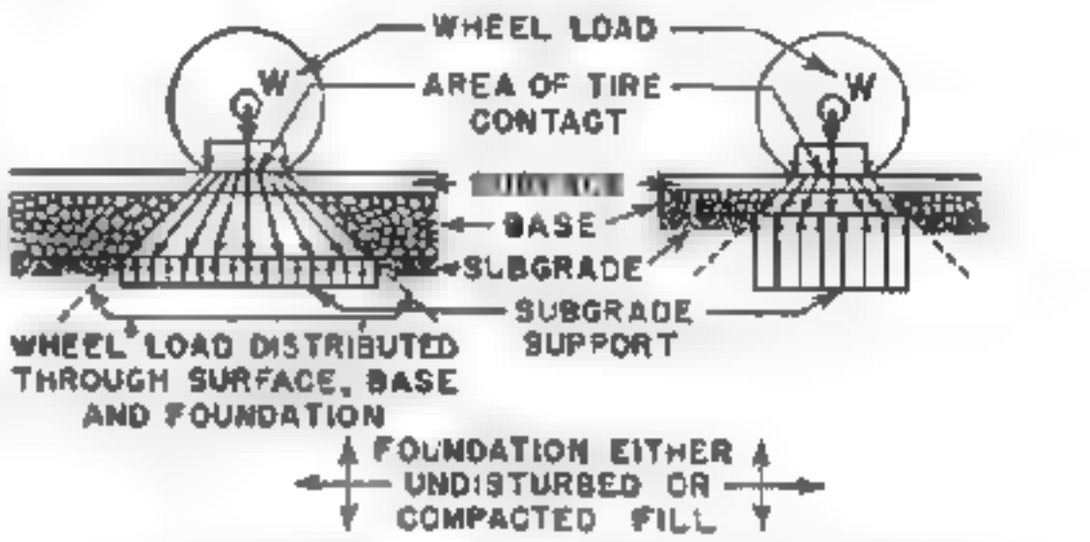

FIGURE 133.—Wheel-load distribution on runway.

FIGURE 134.—Airplane concealed with artificial materials—garnished half-top net, artificial trees in foreground.

not end there. It is just as important to keep that field in a condition to be used at all times. Since the field comes under fire of various sorts, engineers must be alert and ready to fill bomb craters and to clean debris, shell fragments, and other foreign material from the runway surface. The maintenance of camouflage practice and discipline is also the engineers' job.

b. Equipment.—Aviation engineers are given much heavy machinery—bulldozers, power shovels, road graders, tractors, trucks. This material must be kept in the best of condition. These powerful machines are the engineer's tools; without them he cannot do his job. To fill a crater made by a 300-

FIGURE 135.—Airplane concealed with aid of natural materials—net garnished with local foliage

pound bomb means that 90 tons of material must be moved. With his heavy equipment, the aviation engineer can do the job in a short time; without his equipment, the job will be done too late to help the air force, too late to keep the field serviceable, too late to allow our mission to be successful. *Your equipment must be ready.*

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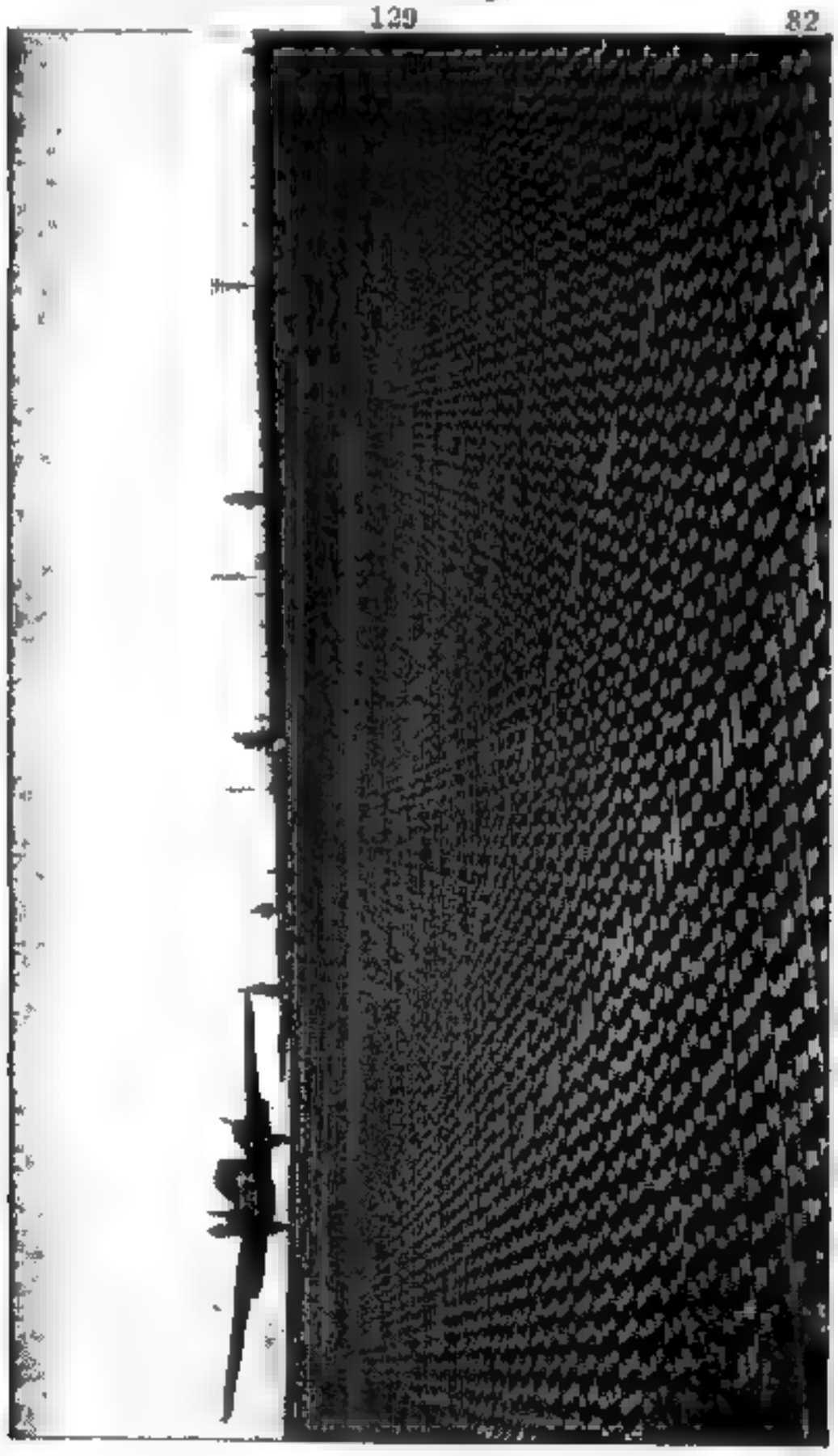

FIGURE 136.—Medium bomber landing on steel mesh runway.

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FIGURE 137.—Laying pierced plank steel runway.

FIGURE 138.—Laying Irving grid steel runway.

131 82

FIGURE 139.—Laying bar-and-rod type steel runway.

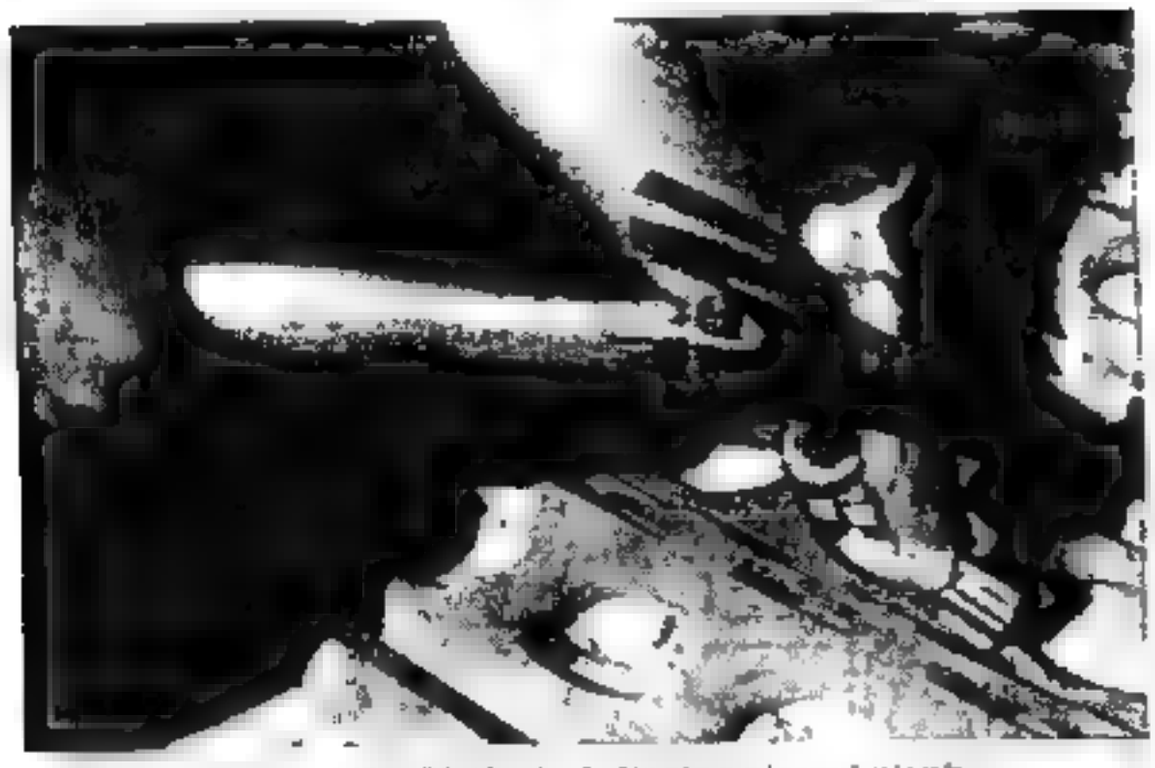

FIGURE 140.—Method of clipping pierced plank.

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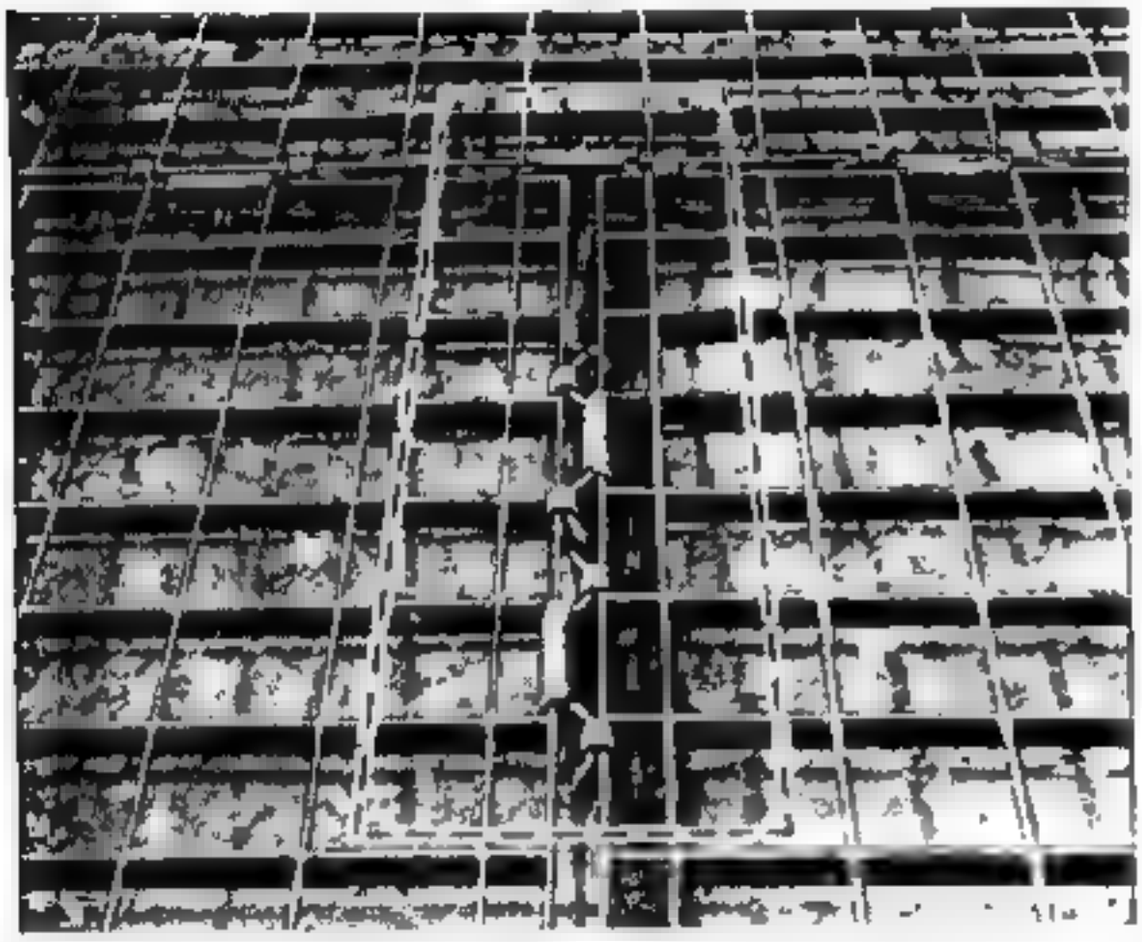

FIGURE 141.—Method of fastening bar-end-rod steel plank. (Similar connection used with Irving grid.)

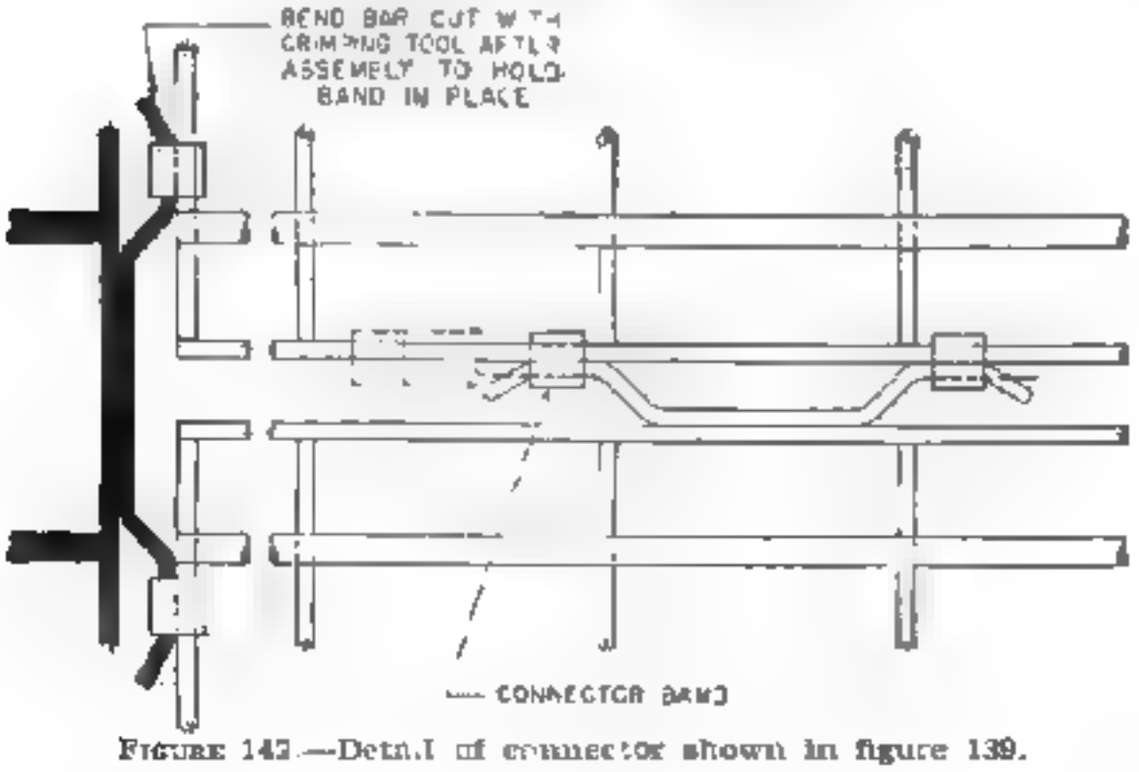

FIGURE 142.—Detail of connector shown in figure 139.

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■ 83 KEEP 'EM FLYING.—Like other Army engineers, the aviation engineer must do his utmost to prevent anything from hindering the forward and continued movement of our forces. Sure it's a tough job, but engineers are tough soldiers. The construction and maintenance of an airfield is one of the stiffer challenges thrown to the engineer. We are meeting it successfully. Whether we continue to win the "battle of the airfields" depends upon how well you learn your job and upon the courage with which you carry it out. Keep 'em flying!

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CHAPTER 12

ENGINEER RECONNAISSANCE

■ 84. GENERAL.—Reconnaissance means the obtaining of information by going out and getting it. Engineers need a great deal of special kind of information to carry out their jobs. As an engineer soldier you may frequently accompany a reconnaissance party; you must know what you are looking for. A good engineer reconnaissance man has two essential qualities:

a. He must be continually alert.

b. He must be able to determine the importance to an engineer of everything he sees.

■ 85. WHAT TO LOOK FOR.—You should, at all times, be alert to engineer needs for information. Some of the things which engineers are interested in are—

a. Engineer materials.—(1) Lumber piles

(2) Quarries and gravel pits

(3) Standing timber.

(4) Civilian building materials, machines, and tools.

(5) Standing buildings which may be repaired, or whose lumber may be used for other purposes.

(6) Road-building materials.

b. Roads.—(1) Condition.

(2) Type (earth, hard-surface, etc.)

c. Bridges.—(1) Condition

(2) Length.

(3) Type.

(4) Number and size of stringers.

d. Obstacles.—(1) Type.

(2) Extent.

e. Streams.—(1) Width.

(2) Depth.

(3) Current.

(4) Banks.

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(5) Approaches.

(6) Dams.

f. Utilities.—(1) Power and communication lines.

FIGURE 143.—Clearing and grading runway using bulldozers, typical pieces of heavy aviation engineer equipment

(2) Water supply facilities.

■ 86 WHAT TO DO ABOUT IT.—*a.* The things you see are useful only if the information can be used, *in time*, by your commander. Once information is secured by a reconnaissance scout, *the first thing to do is to get it to the commander in time to be of use.* A little information in the hands of the commander is better than a lot of information in the hands of a scout who arrives too late

b. Your information should be in writing and arranged in an orderly manner. Your notes should include as many of the essentials as you have time to find out. When you come back you should be able to point out on a map the location of everything you saw.

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CHAPTER 13

THE ENGINEER AND HIS TRUCK

■ 87. ENGINEERS RIDE.—Since engineers pave the way for an army's advance, they must be able to keep up with, and even precede, the fastest-moving elements of the army. Whenever possible, engineers ride in motor vehicles, carrying their tools and equipment with them; however, they must be able to go long distances on foot when necessary, and work and fight afterward

■ 88. YOUR RESPONSIBILITY TO YOUR VEHICLE.—Means of transportation is as important to an engineer soldier as a rifle is to an infantryman. The engineer works with tools and gets to the scene of trouble quickly; his truck contains his tools, collects his materials, and gets him to the job; in fact, his job is built around his equipment. Therefore, one of your most important duties is to keep your vehicle in perfect condition. You are a useless engineer if you can't get to the scene of action in time you are a useless engineer if you can't bring your tools with you.

■ 89. CARE OF VEHICLES.—The good condition of your truck depends on proper driving, proper lubrication, proper and prompt maintenance. All three are important; all three demand your utmost attention. Treat your vehicle like a strong but temperamental horse

a. Give it its due share of attention.

b. Don't fail to give it the right amount of water and oil at the right time.

c. Keep it clean.

d. Inspect it carefully and frequently and tighten all loose parts.

e. Attend *at once* to anything that needs to be repaired or replaced

f. Think of and attend to the needs of your vehicle before you think of your own needs.

g. Learn all you can about good driving. Every engineer soldier who drives or maintains a vehicle should read FM 25–10 in order to be a better driver, a better engineer, a better soldier.

137 90–91

CHAPTER 14

COMBAT WEAPONS

■ 90. FIGHTING ENGINEERS.—The big job of engineers is construction and demolition in order to assist our movement and hinder that of the enemy. That job doesn't leave much spare time for fighting However, the engineer is a scrapper and is given combat weapons with which to protect himself at work and so that he can reinforce the infantry when necessary.

■ 91. COMBAT WEAPONS.—The principal weapons of the combat engineer and their characteristics are as follows:

a. Hand grenades.—(1) *Offensive grenades.*—Depend upon blast effect only. No fragmentation. Effective bursting radius—5 yards. Should be used when thrower lacks cover to protect himself from flying fragments. Can be used for light demolitions and as priming charge for heavier demolitions.

(2) *Defensive grenades.*—Fragmentation type. Bursting radius—30 yards. Can cause casualties up to 200 yards. Should be thrown from covered positions, or into fox holes trenches, or other enclosures, to prevent injuries to thrower. An excellent weapon against crew-served weapons in emplacements.

(3) *Smoke grenades, WP or HC.*—Used to conceal your own activities, or to blind the enemy and hamper his fire and movement. HC has a slight irritant effect. WP can cause severe burns.

(4) *Frangible grenades.*—For antitank incendiary use Consists of a glass bottle filled with gasoline, or other inflammable material with an igniter, which causes it to burst into flame when broken. Effective when thrown into open tank hatches or air intake ports.

(5) *Thermite grenades.*—For destruction of material Emits white-hot molten metal that burns through light

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metal. Useful in igniting gasoline or oil in drums or other inflammable materials in metal containers.

b. Antitank rifle grenade discharger.—A short-range antitank rifle grenade, projected from a discharger fitted on a caliber 30 rifle. Maximum range against tanks is 75 yards. Penetrates any known light or medium tank. Penetration not influenced by range

c. Antitank rocket discharger ("bazooka").—An armor-piercing weapon that breaches armor of any known light or medium tank. Much more powerful than antitank rifle grenade. Maximum effective range under favorable conditions is 300 yards, beyond which it is comparatively inaccurate. Penetration not affected by range. Primarily an antitank weapon, though it may be used effectively against crew-served weapons and point targets other than tanks

d. Bayonet.—For shock action. All crack troops are good bayonet fighters.

e. Pistol, caliber .45.—A self-loading weapon carried by senior officers for close protection.

f. Submachine gun, caliber .45.—A short-range automatic weapon, excellent for close combat in an emergency situation.

g. Carbine, caliber .30.—A self-loading weapon, very effective up to 300 yards. An excellent medium-range rifle, very light and handy. Issued to company officers, key noncommissioned officers, officers, and messengers in combat battalions; is basic arm for rear area.

h. Rifle, caliber .30, M1.—A self-loading weapon, very effective up to 600 yards. The fundamental engineer combat weapon and the best of its type.

i. Machine gun, caliber .30, heavy.—A water-cooled automatic weapon, capable of a high rate of sustained fire. Used to provide base of fire in attack. Lays down final protective lines and covers sectors of fire in organized defenses. Excellent for covering mine fields and obstacles to prevent their removal. Covers approaches to bivouacs and working parties.

j. Machine gun, caliber .30, light.—Automatic air-cooled weapon, with a comparatively low rate of sustained fire

k. Machine gun, caliber .50.—When suitably mounted an effective anti-aircraft weapon, especially when rounds in belt contain mixture of tracer, armor-piercing, and incendiary

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bullets. Also excellent for knocking out trucks and lightly

armored vehicles.

■ 92 GENERAL.—The following fundamentals should be remembered by every soldier—

a. Know your weapons and be able to hit with them.

b. Always take your weapons to work and keep them ready for use Every job must have local security.

c. Shoot only when you have something to shoot at and are reasonably sure of hitting your target. It is a recruit trick to disclose a maneuver or position by firing too soon. This probably is the worst individual mistake in combat.

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APPENDIX I

ENGINEER ORGANIZATIONS AND ENGINEER

■ 1. ENGINEER ORGANIZATIONS.—The Corps of Engineers does many different kinds of work. Much of this work is of a special technical nature. It is so technical, in fact, that whole engineer units—companies, battalions, regiments—are designed to do only one particular kind of job. Following is a list of some of the types of engineer units and what they do.

a. *Engineer general service combat units.*—The basic engineer units are combat troops of various kinds, and can be used for any type of engineer work These include—

(1) *Airborne battalion.*—Combat engineers for airborne division.

(2) *Armored battalion*—Combat engineers for the armored force.

(3) *Combat battalion.*—Combat engineers for infantry division.

(4) *Mountain battalion*—Combat engineers for mountain division.

b. *Engineer special units.*—(1) *Aviation regiment.*—Does work similar to the aviation battalion, but operates where a large volume of work is concentrated in a small area.

(2) *Aviation battalion.*—Builds, defends, and maintains airfields; uses much heavy equipment.

(3) *Airborne aviation battalion.*—Makes hasty repairs to captured airdromes for early use by our air forces.

(4) *Air force headquarters company*—Performs necessary drafting designing, surveying, planning, reproduction, and camouflage work for the air force engineer.

(5) *Camouflage company, camouflage battalion.*—Supply camouflage materials' supervise and inspect camouflage installations.

(6) *Depot company.*—Operates engineer supply depots for field units.

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(7) *Dump truck company.*—Operates and maintains a fleet of dump trucks for use in engineer work.

(8) *Equipment company.*—Furnishes operators and heavy engineer equipment.

(9) *Forestry company.*—Operates sawmills and supplies lumber to engineer units.

(10) *General service regiment.*—Highly skilled carpenters, operators, and builders; uses much heavy equipment.

(11) *Heavy shop company.*—Does heavy repair work for heavy engineer equipment.

(12) *Light equipment company.*—Furnishes light mobile construction equipment for combat battalion.

(13) *Maintenance company.*—Does third echelon maintenance on all kinds of engineer equipment, but not on vehicles which are for ordnance use.

(14) *Ponton company, ponton battalion.*—Maintain, transport, and build floating bridges.

(15) *Separate battalion.*—Large labor unit; builds roads, buildings, airfields, etc.

(16) *Topographic companies, topographic battalions.*—Make and reproduce maps of all kinds for field forces

(17) *Treadway bridge company.*—Maintains, transports, and builds the steel treadway bridge of the armored force.

(18) *Water supply company.*—Uses mobile purification units and tank trucks to purify and supply drinking water.

■ 2. ENGINEER SPECIALISTS.—Experience and skill gained in many civilian occupations are especially needed in engineer units. In every engineer unit there are numerous specialists who receive high ratings. Qualifications for occupational specialists are prescribed in AR 615–26. The number in parentheses is an important part of each specialist designation. Some of the many specialist designations most needed in general engineer units are listed below, together with similar civilian occupations from which such specialists are usually secured

Military specialists	*Civilian occupations*
Blacksmith (024)	Machine-shop blacksmith, blacksmith, forge shopman, or general blacksmith.

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Military specialists	*Civilian occupations*
Bridge carpenter (053).	Mine carpenter, railway carpenter, mine timberman, general construction carpenter.
General carpenter (060)	House carpenter, mill carpenter, carpenter's helper.
Chauffeur (245)	Chauffeur automobile driver, road tester, automobile mechanic.
Demolition man (027)	Explosive man, quarry foreman mine boss.
Draftsman, general (070)	Detailer and tracer, draftsman.
Electrician, general (078)	Wireman, light wireman electrician
Jackhammerman (190).	Pneumatic tool operator, riveter, boilermaker.
Mechanic, general (131).	Skilled helper, handy man (must be able to work from simple drawings or sketches)
Operator, air-compressor (699).	Air-compressor operator automobile mechanic, tractor driver
Painter, general (144)	Fresco painter, large sign painter, house painter.
Pipe fitter (162)	Steam fitter, plumber.
Rigger, general (189)	Machine erector, structural steel erector, bridge erector.
Road roller operator (244).	Same as tractor driver.
Sheet metal worker (201).	Tinsmith, plate worker.
Storekeeper (186)	Receiving and shipping clerk, shipping clerk, warehouse clerk
Tractor driver (244)	Portable gasoline engineerman, tractor field expert, tractor demonstrator, truck driver.
Welder (256)	Welder, subdivisions, blacksmith, general
Winch operator (063)	Hoister engineerman, stationary en-

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APPENDIX II

ENGINEER INSIGNIA

The turreted castle (fig. 144) is the distinctive insignia of the Corps of Engineers. It was first used during the Revolutionary War and has been used in various forms since that time. Introduced by French officers, who were part of our

first Corps of Engineers. It apparently was modeled after one of the gates of the city of Verdun, France It differs from engineer insignia now in use by any foreign army. The turreted castle serves as a reminder of fortification work which has been an important task of military engineers from ancient times up to the present.

Engineer colors are scarlet and white. The chief color, scarlet (used by both artillery and engineers), is more prominently displayed. White is used as a piping (edging) or for similar purposes, as on the engineer hat cord and guidon.

The officers of the Corps of Engineers do not wear the button with the coat of arms of the United States which is worn by all other officers. They have a different button bearing a fortification (fig. 144) modeled after an early structure on Governor's Island in New York harbor. The motto "Essayons" is French for "Let us try." It also dates back to the time of the Revolution and shows the early influence of the French engineers.

a Enlisted man's collar ornament. b Officer's coat button.

FIGURE 144.—Engineer insignia.

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The colors (flags) of engineer organizations consist of two silk flags with fringes; one is the flag of the United States and the other that of the engineer organization. The latter is scarlet embroidered with a coat of arms similar to that of the United States, except that the shield and crest of the organization are substituted for those of the United States seal. Streamers with the same distinctive colors of corresponding service ribbons, attached to the head of the staff of the engineer organization color, show battle honors (military campaigns) in which the unit has taken part. Many organizations have a coat of arms symbolizing the history of the organization which, in some cases, dates back to the Mexican and Civil Wars.

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APPENDIX III

PROFICIENCY TESTS FOR ENGINEER SOLDIERS

In this mechanized war we are fighting, you have an increasingly important role. You are trained to fight; but more important, you are trained as a technical specialist to do all types of engineering work required to aid the advance of our troops and to stop the advance of the enemy. Theoretically, each engineer unit is a team of specialists trained to do a certain task Actually, the uncertainties of war require every engineer soldier to know the fundamentals of every branch of military engineering For example, you must know how to place a demolition charge that will be sure to go off when you fire it. One or two of you may be detailed to demolish an important structure. You *must not fail*. In fast-moving war, you may find yourself manning a 37-mm antitank gun or a caliber .50 machine gun when you are not a regular member of the crew. You must be proficient in all measures of individual protection and security. You must know your *engineering* and your *combat principles*.

The proficiency tests that follow give you a chance to check up on what you have been taught, to review the things you must know, and to record your progress toward the standard set for you.

Carry this book with you during duty hours. As soon as you feel qualified to answer the questions or perform the tasks of a test, see your nearest company officer He will conduct a test as soon as practicable. If you pass, he will initial the question or demonstration and record his name The development of your abilities as an engineer soldier has an important bearing on your progress in the Army.

CHECK LIST No. 1—*General*

1. What is the name and rank of your battalion commander?

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2. What is the name and rank of your company commander?
3. What is the name and rank of your platoon commander?
4. What are the names and ranks of the other company commanders in the battalion?
5. What clothing and equipment do you carry in your combat pack, roll, barracks bag?
6. Are the data on your identification tags correct? Why are the tags tied as they are?
7. What information will you give the enemy, if captured?
8. Using your mess gear, demonstrate how to prepare coffee, cocoa, stew, boiled potatoes, fried eggs, and bacon?
9. Under what circumstances do you lay aside your rifle when working?
10. *a.* How would you draw your pay if you were separated from your unit?

b. What entries must be made in your Soldier's Pay Card (W. D., A G O Form 28 p. 2), before you can do so?

CHECK LIST No. 2—*Unit organization and equipment*

1. What bridge equipment does a combat battalion carry in the field?
2. How many reconnaissance boats are there in a combat company?
3. *a.* What pneumatic tools are there with the compressor truck?

b. How many of these tools may be used at the same time?

c. How and for what purpose are they used?

4 Name tools carried in your squad pioneer, carpenter, and demolition chests.
5. What quantities of the following expendables are ordinarily carried with the squad sets: explosives, fuze, caps, rope, wire, sandbags?
6. Demonstrate how to place tools in proper places in squad boxes.
7. What transportation is assigned to your unit?
8. What is the strength of your company?
9. What is the strength of your battalion?

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CHECK LIST No. 3—*Bridges, fixed and floating*

1. Define following terms applied to bridges:

Abutment	Suspension
Approach	Floor beams
Truss	I-beams
Girder	Reinforcing
Pier	

2 Identify following parts of ponton, assault, and reconnaissance boats:

Valve	Capstan
Balk fastener	Bow
Paddle	Cleat
Oar	Bulkhead

Gunwale Stern

3 Know how to carry, launch, and paddle an assault boat silently. Know how infantry are loaded.

4. Know how to carry, launch, and paddle a reconnaissance boat.

5 Know how to carry launch, and row a ponton boat.

6 Know how to repair a rubber boat.

7 Know how to carry bank and chess.

8 Know parts of abutment of any bridge and their relation to each other.

9 Identify the following parts of the standard timber and trestle bridge:

Cap	Treads
Sill	Bracing
Post	Span
Bent	Abutment sill
Stringer	End dam
Curb	Approach
Footing	Roadway
Floor	

10. Know how to strengthen an existing bridge.

11. Identify the following parts of floating bridges:

Balk	Trestle
Chess	Raft
Siderail	Abutment sill
Siderail clamp	Ponton
Holdfast	Bay
Hinge span	Pneumatic float

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12. Know what working parties are required for construction of a footbridge and duties of each.

13. Know what maintenance is required on a ponton bridge

14 Know the regulations for traffic using a ponton bridge.

15 Know how to construct a float using rifles and shelter halves.

16 Know how to construct a raft using 55-gallon gasoline drums, 3-inch planks, and ¾-inch rope.

Check List No. 4.—*Camouflage*

1. Know the purpose of camouflage

2. Know types of observation against which camouflage is required.

3. Know how and with what to camouflage the following:

a. Yourself.	d Your truck.
b Your foxhole.	e. Your machine-gun
c. Your tent,	position.

4. Know how to garnish a camouflage net with natural or artificial materials.

5. Know five precautions to take to preserve camouflage discipline in a bivouac area.

6 Know how to use shadows to hide a truck in the morning; in the afternoon

7. Know how to break up shadows cast by military installations and equipment.

8. Know what camouflage measures should be taken on a march; at a halt.

9 Know how to use natural materials in locating your shelter tent.

10. Know why new tracks must not be formed around a military installation

Check List No. 5.—*Demolitions*

1. Know safety rules for using gunpowder, dynamite, nitrostarch, TNT, primacord, caps

2 Know precautions to be taken before and during firing of a charge.

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3. Know precautions to be taken in event of a misfire

4. Know how to prepare and light safety fuze, using safety match; fuze lighter.

5. How long does it take to burn 1 foot of safety fuze? 6 feet? Test.

6. Know how to prepare a cap and safety fuze for firing.

7. Know difference between time fuze and primacord.

8. Know how to prepare primacord for detonation.

9. Know how to join two pieces of primacord, demonstrate

10. Know how to make a primer using nonelectric cap and fuze; electric cap; detonating cord

11. Know how to make a series connection of electrical caps.

12. Know how to prepare a wire splice correctly

13. Know how to test a circuit by use of the galvonometer.

14. Know cap capacity of the exploders.

15. Know how to fix a demolition charge to—

a. A rail.	c. A girder
b. A post or tree (internal or external).	d. A concrete beam.
	e. An I-beam.

16. Know effect and value of tamping and how to obtain it.

17. Know proper method of placing and firing underwater charges.

18. Know how to handle standard firing devices.

19. Know how to lay and arm an antitank mine.

20. Know three methods of removing an activated enemy antitank mine.

Check List No 6.—*Engineer reconnaissance*

1. Estimate height of building or tree (within 15 percent error).

2. Measure height of building or tree (within 10 percent error) by comparing shadow cast by object with length of your own shadow.

3. Measure gradient of a road with a clinometer.

4. On a map point out places to look for—

Sand	Quarry
Gravel	Water
Timber	

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5. Know what reconnaissance information is needed about—

Roads	Water supply
Bridges	Power and communi-
Obstacles and mine fields	cation lines
Stream crossings	

6. Know what reconnaissance information to send, to whom, when to send it, and where it should be sent

Check List No. 7.—*Field fortifications and obstacles*

1. What is the minimum clearance required in a one-man standing type of fox hole for protection against tanks passing directly over the fox hole?

2. What are the approximate dimensions of a—

One-man fox hole (standing)

Two-man fox hole (standing)

3. Know how to distribute spoil when digging trenches and fortifications.

4. What thickness of loose earth is proof against small-arms fire?

5. Know how to build a wall revetment.

6. Know how a double-apron fence is constructed.

7. Know the fastenings for barbed wire on screw pickets.

8. Know how to cut a path through wire fence with wire cutters.

9 Know how to prepare and place a bangalore torpedo for cutting path through wire fence.

10. Know how to build at least two kinds of log tank obstacles

11. Know the minimum dimensions of antitank ditches required to stop tanks

12. Know what type locations are suitable for road blocks.

13. Know how to make a hasty emplacement for heavy machine gun, caliber .30.

14. Know how and why obstacles are *covered* by fire. Know how and why they are *protected* by fire

15. Know how to install obstacles against airplanes attempting to land.

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CHECK LIST No 8.—*First aid—military sanitation—sex hygiene*

1. Know what first-aid equipment is in your first-aid packet.

2 Demonstrate first aid you would give in case of—

a. Drowning.
b. Bad knife wound in arm; in neck
c Broken leg.
d. Shock

3. Know best method of preventing venereal disease.

4. Know what to do in case you contract venereal disease.

5. Know how to take care of your feet on long marches.

6 Know how to prevent spreading your "cold."

7. Know how to chlorinate a canteen cup of water.

8 Know another method of purifying a canteen cup of water in the field.

9. What is water discipline on the march?

CHECK LIST No. 9.—*Gas defense*

1 What is the gas alarm?

2 Know how to put on adjust, test, and remove a gas mask properly

3. Know the field identification of the following military gases by smell:

Mustard	Chlorpicrin
Lewisite	Tear gas
Chlorine	Adamsite
Phosgene	

4. Which gases are vesicants? which are lung irritants? which make you cry?

5. What do you do when you hear the gas alarm?

6 What is the last thing you do before taking off your gas mask?

7. What first-aid measures will you take for a casualty by a vesicant gas? By a lung irritant gas?

8 Know how to decontaminate—

A rifle.
Personal equipment and clothing
A bridge to be prepared for demolition.

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9 Know what action should be taken if a gassed area is found.

10. Know for what purpose protective clothing is used.

CHECK LIST No. 10.—*Knots, lashings, and rigging*

1 Know how to coil and uncoil rope.

2. Know how to tie the following knots and their uses:

Bowline	Fisherman's bend (anchor knot)
Bowline on a bight	Round turn and two half hitches
Square knot	Timber hitch
Sheep shank	Clove hitch
Single sheet bend	Mooring hitch

3. Know how to whip the end of a rope, mouse a hook

4 Know how to make a square lashing

5 Know how to make a short splice; a long splice; an eye splice.

6. Name parts of a set of double blocks, know how to reeve them.

7 Know how to make lashings for gin pole, shears, and tripod.

8. Know where to fix guys to shears and gin pole

9. Know mechanical advantage of various types of tackle.

10. Know precautions to prevent damage to steel cable

11. What is the strength of ½-inch rope? ¾-inch rope? 1-inch rope?

12. What is the strength of ½-inch steel cable? ¾ inch cable? 1-inch cable

13. Know how to make a 3–2–1 picket holdfast.

14. Know capabilities and characteristics of chain; chain hoist; chain ratchet hoist

CHECK LIST No. 11.—*Map reading*

1. Know how to determine grid coordinates of a point indicated on a map.

2. Know how to orient a map with and without a compass.

3. Given two points on a map know how to scale shortest road distance between them, in miles.

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4. Given two points on a contour map, know how to determine their relative heights.

5. Be able to identify on a contour map—

Hill	Saddle
Steep slope	Cut
Streams	Fill
Ridge lines	Marsh

6. Be able to identify on a map—

Railroad line	Bridges
Highway	Church
Trail	School
Crossroad	Fence
Road junction	Telegraph lines
Woods	Buildings

7. Be able to identify on an aerial photograph—

Roads	Houses
Woods	Fields

8. What is the difference between magnetic, true, and grid north?

9. Be able to determine north by watch and sun; by compass; by north star and dipper

10. Know how to determine azimuth from one point to another on map; on ground.

11. Know how to determine slope and visibility from contour map.

CHECK LIST No. 12. *Physical conditioning*

1. Do 28 push-ups.

2. Run 300 yards in 45 seconds.

3. Carry a man of approximately your own weight 75 yards in 20 seconds.

4. Alternately run 10 yards and crawl 10 yards to cover 70 yards in 20 seconds.

5. In full field equipment, march 4 miles in 50 minutes.

6. Run the battalion obstacle course in ——— seconds

7. In full field equipment, run 200 yards to firing point and score at least three hits out of five rounds on a silhouette target in 1 minute at a range of 200 yards

8. In full field equipment march 30 miles in 14 hours.

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9. Demonstrate how to attack a sentry from behind and kill him silently.

10. Demonstrate how to fight with a knife.

11. Demonstrate how to disarm a man armed with a rifle, pistol, knife.

12. Demonstrate at least four paralyzing blows.

13. Jump off in deep water, straighten out, swim 50 yards. Swim 25 yards in full uniform.

CHECK LIST NO. 13.—*Roads*

1. What is the most important thing to remember in all road construction?

2. What is the width of a one-lane road? Of a two-lane road?

3. Know characteristics of a road made with:

Earth	Gravel
Wire mesh	Macadam
Sandbags	Bituminous material
Corduroy	Concrete
Plank tread	

4. Know following items of equipment and what they are used for:

Plow	Roller
Scraper	Power shovel
Angledozer	Dragline
Blade grade	Rooter
Scarifier	

5. Know the meaning of the following terms:

Clearing	Shoulder
Grubbing	Culvert
Subgrade	Riprap
Drainage	Scour
Road metal	Revetment
Aggregate	Gradient
Crown	Ditch
Headwall	

6. Know how to repair a crater in a road.

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CHECK LIST NO. 14.—*Rough carpentry*

1. Know how to lay out a right angle by the 3–4–5 method.

2. Know how to square abutments with center line of a bridge.

3. Using level, square, and chalkline, know how to square a round timber; a cap.

4. Know how to plumb an upright, using a level.

5. Be able, using a carpenter's square, to mark a timber for a 45° cut.

6. Drive 10 consecutive nails without bending one.

CHECK LIST NO. 15.—*Tools and their use*

1. Know correct use of pick and shovel.

2. Know proper use of a gooseneck wrecking bar.

3. Know proper use of a carpenter's adz; a hatchet.

4. Know proper handling of a chopping ax; of a hand saw, a two-man saw.

5. Know how to use a peavy correctly in handling a 12-inch log.

6. Know how to fell a tree in a given direction.

7. What is the difference between a crosscut and a rip saw?

8. Know how to sharpen an ax.

9. Know how to operate properly the gasoline-driven chain saw.

10. Know how to operate properly the following compressed air tools, timber chain saw, rock drill, auger, circular saw, air hammer.

CHECK LIST NO. 16.—*Weapon training*

1. How many rounds fill the magazine of a—
   a. U. S. rifle, M1.
   b. U. S. rifle, M1903.
   c. Submachine gun, caliber .45.
   d. Carbine.
2. Know sight picture of weapon with which you are armed.
3. With rifle with which you are armed, know how to—
   a. Zero rifle.
   b. Use sights.

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   c. Aim.
   d. Press trigger.
   e. Fill clips, and load clip into magazine.
   f. Load and fire piece.
   g. Clean after firing.
4. Know how to load, aim, and fire following weapons:
   a. Heavy machine gun, caliber .30, M1918.
   b. Machine gun, caliber .50 HB.
   c. Antitank rifle grenade.
   d. Rocket launcher.

5. What is effective range, maximum range, and normal rate of fire of weapon with which you are armed?

6. Know how to field strip and name all parts of weapons with which you are armed.

7. How do you identify ball ammunition, blank ammunition, tracer ammunition, armor-piercing ammunition, dummy ammunition?

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GUIDE TO SELECTED VIET CONG EQUIPMENT AND EXPLOSIVE DEVICES

May 1966
Headquarters, Department of the Army
Washington, D.C.

DEPARTMENT OF THE ARMY PAMPHLET 381–11

FOREWORD

The purpose of this handbook is to provide United States military personnel with a compact source of orientation and recognition data on improvised equipment and explosive devices in use by the Viet Cong in the Republic of Vietnam.

The Viet Cong forces have acquired wide experience in constructing grenades, mines, fuses, explosive charges, and other deadly weapons and devices by using commonly available materials. These devices, cunningly placed and camouflaged, have caused many casualties.

The authority for retention of war trophies by any individual is governed by directives of the senior U.S. Headquarters in the area concerned, as well as by pertinent regulations. Items of war materiel coming into the possession of U.S. forces will be reported through intelligence channels.

Evidence of errors or omissions in this handbook should be forwarded to the U.S. Army Foreign Science and Technology Center, Munitions Building, Washington, D.C., 20315.

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No. 381-11

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *27 May 1966*

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EMERGENCY HANDLING GUIDANCE FOR EXPLOSIVE DEVICES

(Extracted from FM 5–31, September 1965)

1. GENERAL

Through knowledge of the mechanical details and techniques in the use of standard U.S. mines, grenades, and boobytrapping equipment, a soldier is ordinarily prepared to some extent for dealing with similar equipment of the enemy. However, familiarity with conventional warfare explosive devices is of little or no use in guerrilla warfare. Most enemy boobytraps found recently in guerrilla-infested areas were cunningly and ingeniously improvised and laid. Such boobytraps can rarely be neutralized, even by the most experienced specialists.

2. TECHNICIANS

a. Although engineer and infantry specialists are responsible for boobytrap detection and removal, men in all military organizations assigned to combat zone missions must be trained to assist them.

b. If possible, trained engineer, infantry, or explosive ordnance disposal (EOD) units will search out and neutralize all boobytraps in front of friendly troops—or prepare safe passage lanes. Simple boobytraps will be disarmed during attack; those more complicated will be marked by warning signs and reported for removal.

c. Tactical units should bypass boobytrapped areas, especially villages and other inhabited places, to be cleared by specialists later. They will neutralize boobytraps only when necessary for continued movement or operation.

3. DETECTION

Detection of boobytraps requires the most careful observation. Soldiers must discipline themselves to be constantly on guard against the possibility of accidentally exploding a boobytrap, especially when moving over an area previously held by the enemy. All soldiers, even those not assigned primary responsibility for locating boobytraps, must be alert for any sign of them. They must always look carefully for concealed boobytraps even when performing normal activities.

4. OUTDOOR SEARCH TECHNIQUES

As boobytraps are so deadly and so cunningly conceived and hidden, searchers should be suspicious of—

a. All movable and apparently valuable and useful property.

b. All disturbed ground and litter from explosive containers.

c. Marks intentionally left behind to attract or divert attention.

d. Evidence of former camouflage.

e. Abrupt changes or breaks in the continuity of any object, such as unnatural appearance of fences, paint, vegetation, and dust.

f. Unnecessary things like nails, wire, or cord that may be part of a boobytrap.

g. Unusual marks that may be an enemy warning of danger.

h. All obstructions, for they are ideal spots for boobytraps. Search carefully before lifting a stone, moving a low-hanging limb, or pushing aside a broken-down wheelbarrow.

i. Queer imprints or marks on a road, which may lead a curious person to danger.

j. Abandoned vehicles, dugouts, weeds, machinery, bridges, gullies, defiles or abandoned, stores. Walk carefully in or around these as pressure-release devices are easily concealed under relatively small objects.

k. Areas in which boobytraps are not found immediately. Never assume without further investigation that entire areas are clear.

l. Obvious tripwires. Even though one tripwire is found attached to an object, others may be also attached. Searching must be complete.

5. DISARMING METHODS

a. Neutralisation. Neutralization, the making of a dangerous boobytrap safe to handle, involves two steps: (1) disarming or replacing safeties in the firing assembly, and (2) defuzing or separating the firing assembly from the main charge and the detonator from the firing assembly. If neutralization is not possible, the boobytrap must be destroyed.

b. Destruction in Place. A boobytrap may be destroyed in place if some damage is acceptable, as is generally the case out of doors. An operator may initiate a boobytrap by its own mechanism and riggings or by a rope from a safe distance (at least 50 meters away).

c. Removal of the Main Charge. Before attempting removal, careful probing around the main charge is necessary to locate and neutralize all antilift devices. To avoid casualty, the type of firing mechanism must be recognized and all safety devices must be replaced. If complete neutralization seems doubtful, the charge should be pulled from place by a grapnel or rope from a safe location (at least 50 meters away). After pulling the charge, the operator should wait at least 30 seconds as a safeguard against a concealed delay action fuze.

d. Hand Disarming. None but trained specialists should attempt hand disarming—unless the boobytrap's characteristics and disarming techniques are well known. Trained specialists *only* should inspect and destroy all unusual or complicated mechanisms. The following procedures for hand neutralization should be used for guidance only, as the exact sequence depends on the type of device and manner of placement.

(1) Do not touch any part of a boobytrap without first examining it thoroughly. Locate all firing devices and their triggering mechanisms.

(2) When tracing wires, look for concealed intermediate devices laid to impede searching. Do not disturb any wires while examining the boobytrap.

(3) Cut loose tripwires only after careful examination of all connecting objects and after replacing all safeties.

(4) Trace taut wires and disarm all connected firing devices by replacing safeties. Taut wires should be cut only after eliminating the danger at both ends.

(5) Replace safeties in all mechanisms, using nails, lengths of wire, cotter pins, and other similar objects.

(6) Never use force in disarming firing devices.

(7) Without disturbing the main charge, cut the detonating cord or other leads between the disarmed firing device and the main charge.

(8) Cut wires leading to an electrical detonator—one at a time

(9) When using a probe, push it gently into the ground. Stop pushing when you touch any object (it may be a pressure cap or plate).

(10) Once separated, boobytrap components should be removed to a safe storage or disposal area.

e. Special Precautions.

(1) Be very cautious in handling delay mechanisms. Danger may exist before the appointed time because of auxiliary firing devices. All complicated and confusing devices should be destroyed in place or marked for treatment by specialists.

(2) Wood or cardboard explosive containers, buried for long periods of time, are dangerous to disturb. They are also extremely dangerous to probe if in an advanced state of decomposition. Deteriorated high explosives are especially susceptible to detonation. Thus, a boobytrap destroyed in place and in a concentrated area long exposed to moisture may detonate many others simultaneously.

(3) Metallic explosive containers are often dangerous to move after prolonged burial. They may also be resistant to detection because of oxidation. The explosive may become contaminated after a time, further increasing the danger of handling. Explosives containing picric acid are particularly dangerous; deterioration from contact with metal forms extremely sensitive salts which are readily detonated by handling.

(4) Certain types of fuzes become extremely sensitive to disturbance after exposure to wet soil. Detonation in place is the only safe method of neutralizing or removing such deteriorated boobytraps.

SELECTED VIET CONG

EQUIPMENT AND EXPLOSIVE DEVICES

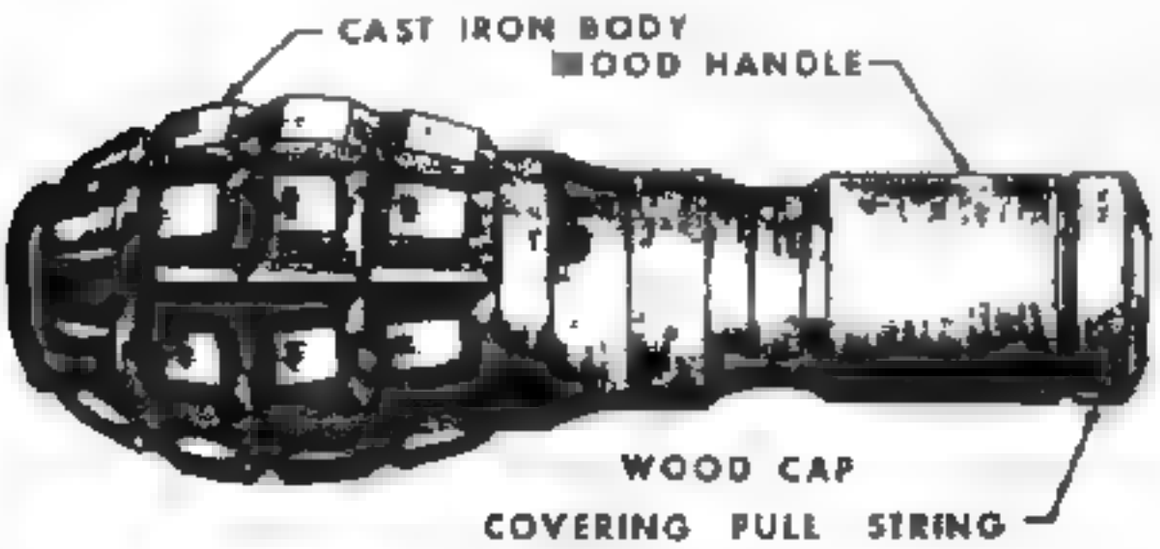
8
Stick Hand Grenade

GENERAL DESCRIPTION AND COMMENT

The stick hand grenade, used extensively by the Viet Cong, comes in several sizes—differentiated by lengths of handle and sizes of fragmentation heads. This grenade functions by a pull string enclosed in the handle and attached to a copper wire coated with a match compound. Normally the match compound ignites a 4-second delay element, but a number of these grenades have been found with no delay element.

CHARACTERISTICS

Type	Defensive
Color	Black
Maximum diameter	2 in
Length	6 to 8 in
Total weight	3 lb
Filler	TNT
Fuze delay	Approx 4 sec



STICK HAND GRENADE

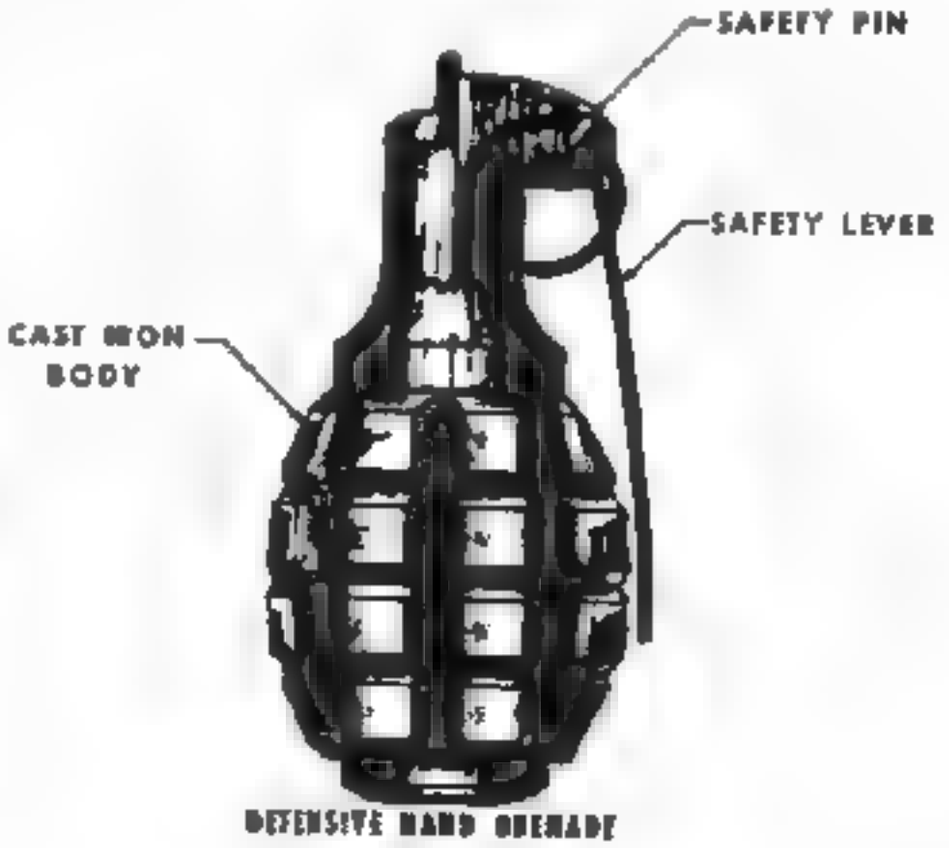
11
Defensive Hand Grenade

GENERAL DESCRIPTION AND COMMENT

The defensive hand grenade, of serrated cast iron, functions in the same manner as similar U. S. hand grenades. When the safety pin is removed and the grenade thrown, the safety lever releases the spring of the mechanical firing device which ignites the primer and delay element of the fuze.

CHARACTERISTICS

Type	Defensive
Color	Black
Diameter	2.5 in
Length	5 in
Total weight	1.5 lb
Filler	TNT
Fuze delay	Approx 4 sec



DEFENSIVE HAND GRENADE

13

Offensive Hand Grenade

GENERAL DESCRIPTION AND COMMENT

The offensive hand grenade is made of explosive and sheet metal with crimped and soldered seams. It is normally equipped with a time delay fuze. These grenades must never be disassembled as a number of them have been found boobytrapped; for example, they have been found with an instantaneous (no delay) fuze, and an attempt to throw such a grenade, after pulling the pin, would prove fatal to the thrower

CHARACTERISTICS

Type	Offensive
Color	Generally black or olive-drab
Maximum diameter	2.6 in
Length	[illegible]
Total weight	1.5 lb
Filler	TNT or potassium chlorate
Fuze delay	Approx 4 sec

OFFENSIVE HAND GRENADE

15

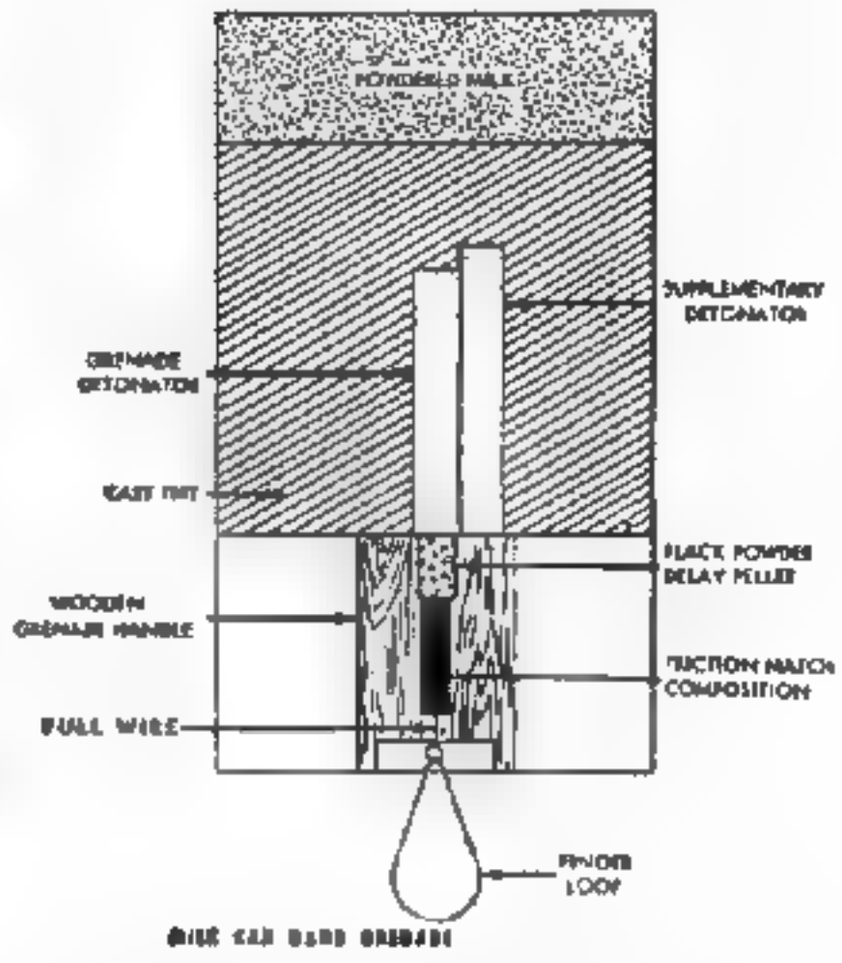
Milk Can Hand Grenade

GENERAL DESCRIPTION AND COMMENT

The milk can hand grenade is made from a commercial powdered milk can by cutting a hole in one end and removing most of its contents, refilling the can with cast TNT, and installing a pull-friction fuze from a stick hand grenade. Because the device has no booster charge, it uses two detonators for more powerful concussion.

CHARACTERISTICS

Type	Offensive
Color	Commercial label
Maximum diameter	3.5 in
Length	6.0 in
Total weight	2 lb
Filler	Cast TNT
Fuze delay	Approx 4 sec



MILK CAN HAND GRENADE

17

Shaped Charge Hand Grenade

GENERAL DESCRIPTION AND COMMENT

The shaped charge hand grenade consists of a shaped charge, a cylindrical sheet metal charge container, a conical sheet metal drag, an impact fuze mechanism, and a wood handle with a sheet metal drag lock and pin. When the lock pin is removed and the grenade is thrown, a spring forces the conical drag back over the handle to stabilize the grenade's flight (drag is attached to charge container by strips of material inside the cone). When the grenade strikes, the impact fuze ignites the shaped charge.

CHARACTERISTICS

Type	Shaped charge (HEAT)
Color	Black or olive-green
Maximum diameter	3 in
Length	8.75 in
Total weight	Approx 1.5 lb
Filler	Cast TNT
Fuze delay	Time of flight

19

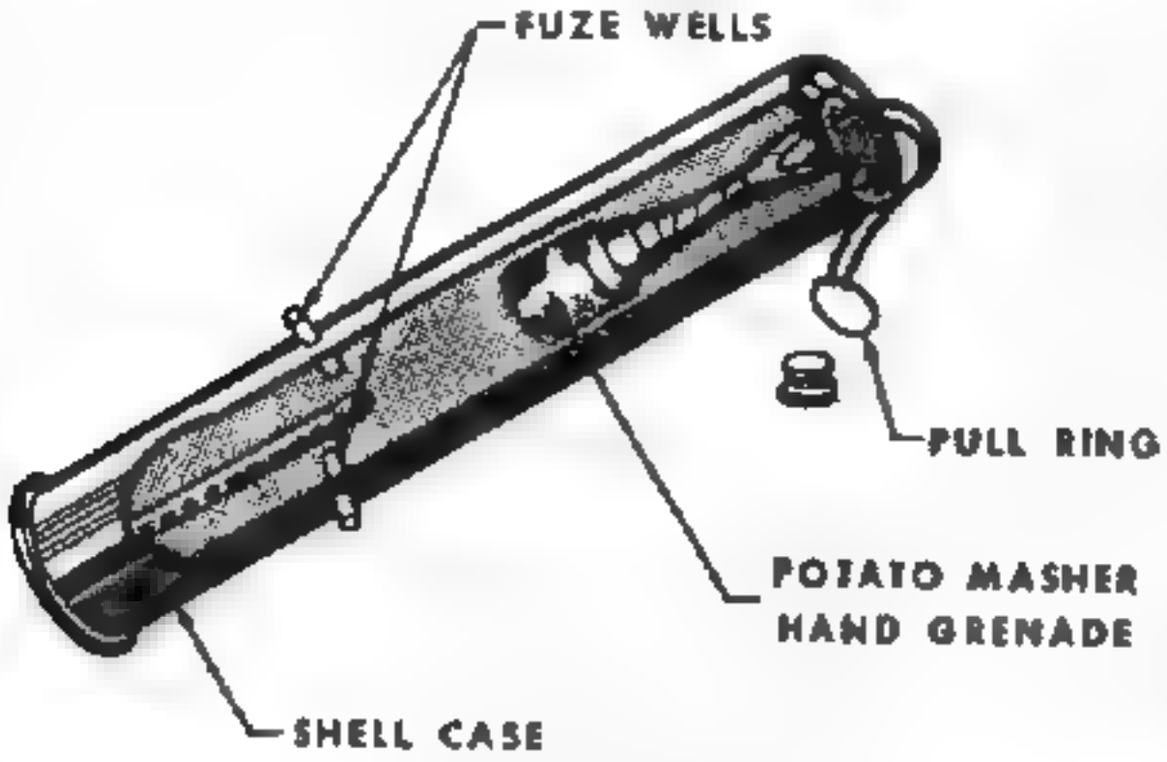
Shell Case Mine

GENERAL DESCRIPTION AND COMMENT

The shell case mine has a standard artillery shell casing, mostly 75-, 105-, and 155-mm calibers. A variety of fuzing mechanisms can be improvised for this mine; the mine illustrated is detonated by the potato masher grenade inserted into the explosive charge. Inserted into the side of the casing are two fuze wells through which electrically or mechanically initiated fuzes may be placed. The mine, generally used in an antipersonnel role, is initiated by a tug on a tripwire strung across a path.

CHARACTERISTICS

Type	Antipersonnel
Color	Brass
Maximum diameter	6 in
Length	18 to 24 in
Total weight	10 to 15 lb
Filler	TNT
Fuze delay	3 to 4 sec (with grenade)



SHELL CASE MINE

21

Tin Can Antipersonnel Mine

GENERAL DESCRIPTION AND COMMENT

The tin can mine is constructed from a sheet metal container similar in appearance to a beer can. The firing device for the explosive is an improvised fuze with zero delay action. A hand grenade fuze may be used with this munition by removal of the delay element. The mine functions by a tripwire attached to the pull ring device, which when removed allows the spring-driven striker to move downward, hitting the primer and detonating the mine.

CHARACTERISTICS

Type	Antipersonnel
Color	Gray or green
Maximum diameter	3 in
Height	6 in
Total weight	Appox 2 lb
Filler	TNT
Fuze delay	None

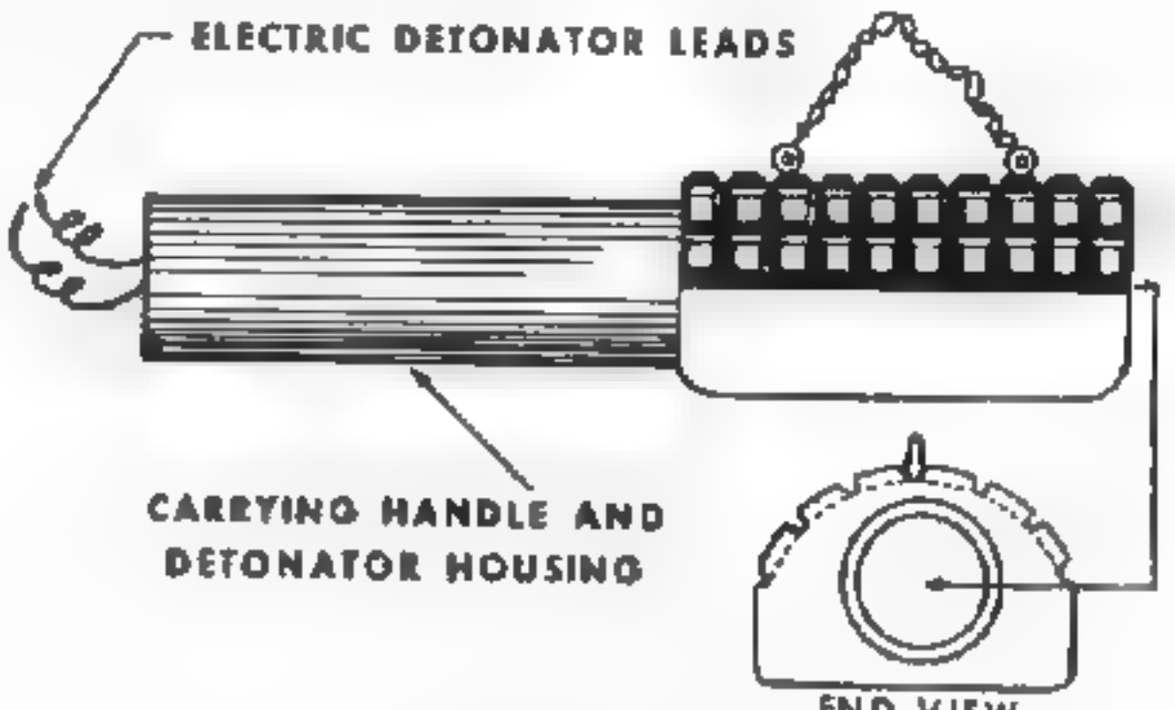
TIN CAN ANTIPERSONNEL MINE

23

Concrete Fragmentation Mine

GENERAL DESCRIPTION AND COMMENT

The concrete fragmentation mine is constructed of explosive encased in cylindrically shaped concrete with a flat side for stable emplacement. A 2-inch-diameter pipe on one end of the mine head serves as a carrying handle and detonator housing. The two swivels on top of the mine are used to tie it to an object. The mine's electrical detonator usually is activated remotely by means of a battery pack or hand held generator.



CONCRETE FRAGMENTATION MINE

25

Concrete Mound Mine

GENERAL DESCRIPTION AND COMMENT

The concrete mound mine is constructed of explosive encased in concrete, but possibly a similar mine of cast iron may be encountered. The mound-shaped mine is electrically fused and has two fuze wells, one at each end. The iron pipe at one end of the mine serves as a pole socket, as well as being a housing for one of the fuze wells. Electric current to activate the detonator is provided by a battery pack or hand-held generator

CHARACTERISTICS

Type	Antipersonnel
Color	Gray
Maximum diameter	5.5 in
Length	14 in
Total weight	13 lb
Filler	TNT
Fuze delay	None

27

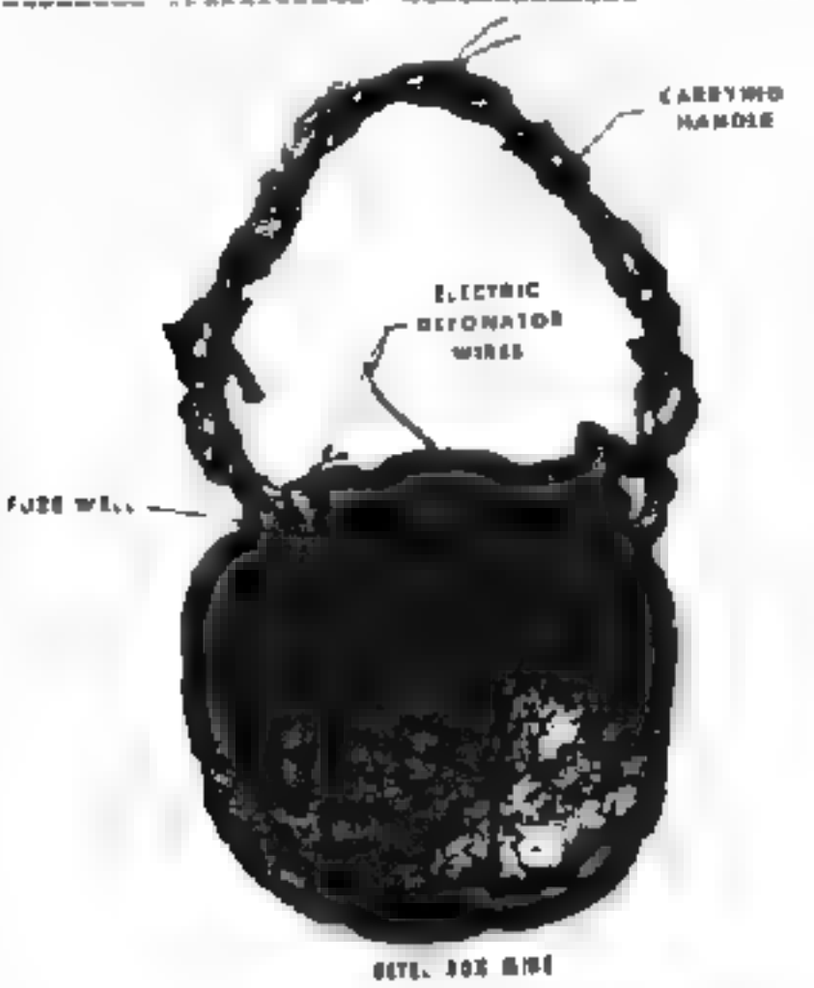
Betel Box Mine

GENERAL DESCRIPTION AND COMMENT

The betel box mine is constructed of concrete and explosive. Its one fuze well is located on the top at the center of the mine. Used in either an antipersonnel or an antivehicular role, the mine is exploded by an electrical detonator.

CHARACTERISTICS

Type	Antipersonnel/
Color	Gray antivehicular
Maximum diameter	8 in
Height	7 in
Total weight	33 lb
Filler	TNT



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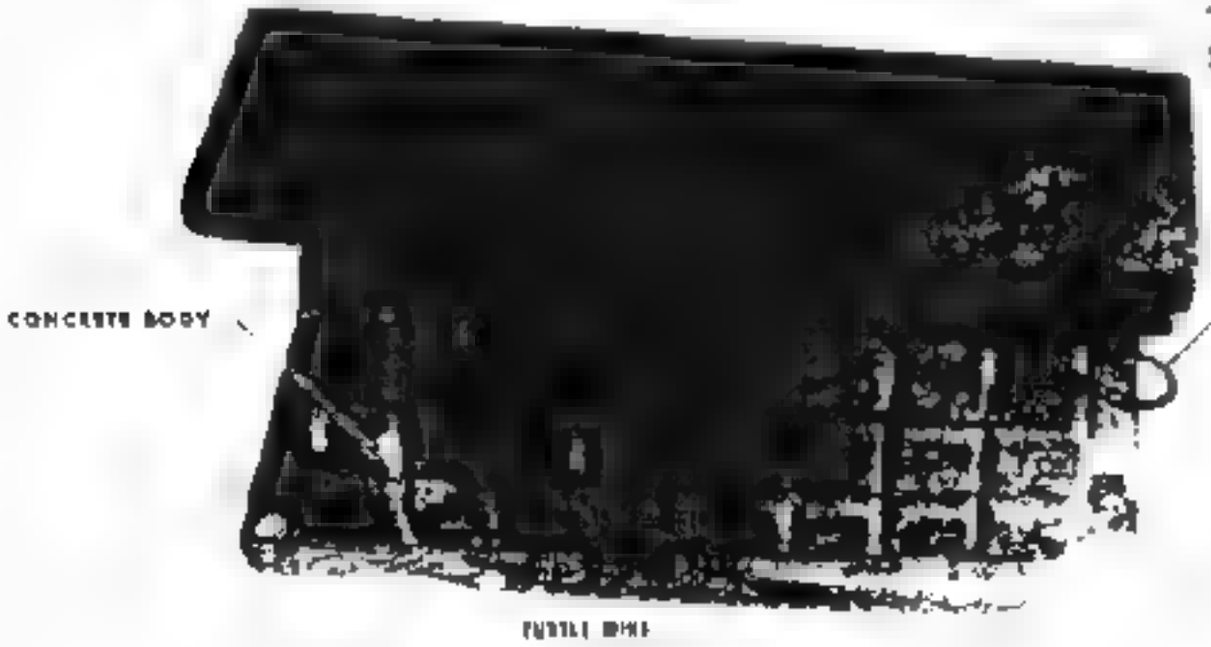
Turtle Mine

GENERAL DESCRIPTION AND COMMENT

The turtle mine, constructed of concrete with explosive inside, is used primarily as a demolition charge. It can be detonated by either an electrical or mechanical fuze (with or without delay). The mine illustrated utilizes a mechanical fuze

CHARACTERISTICS

Type	Dual purpose
Color	Gray
Maximum diameter	5 in (end view of antivehicular)
Length	9 in
Overall weight	13 lb
Filler	TNT



TURTLE MINE

31

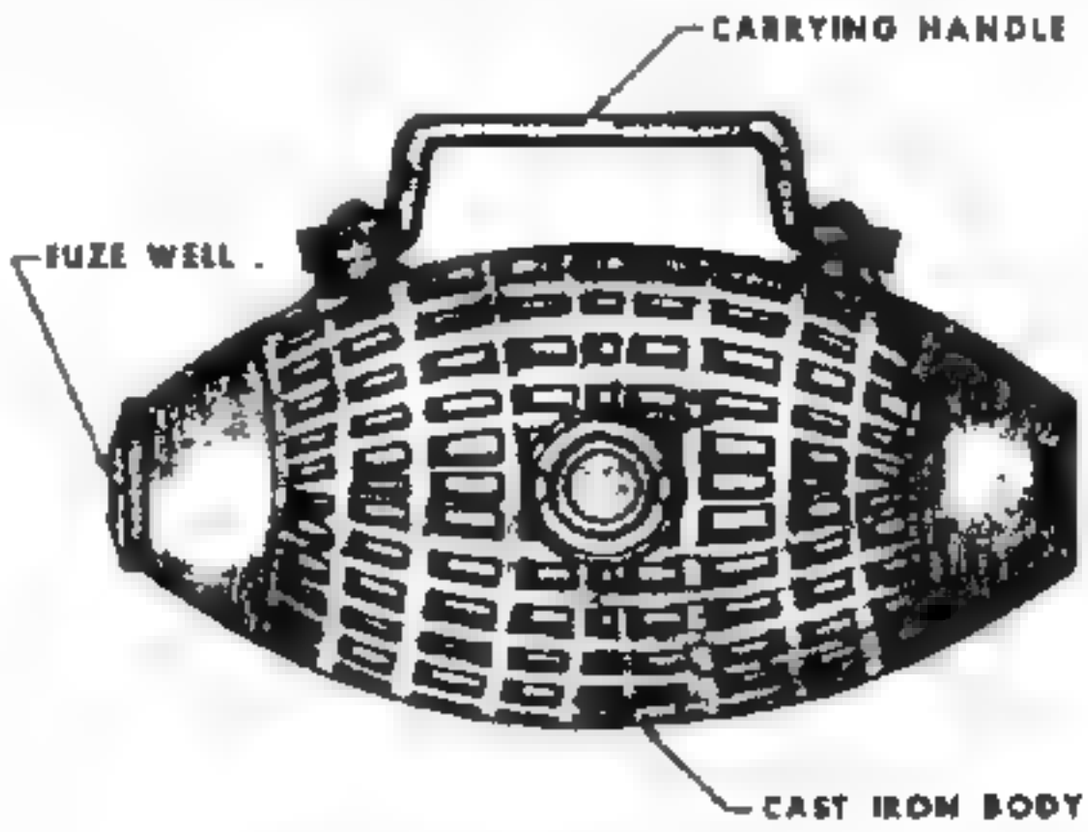
Pineapple Fragmentation Mine

GENERAL DESCRIPTION AND COMMENT

The pineapple fragmentation mine is a unique egg-shaped mine constructed of cast iron and is further identified by surface serrations and a carrying handle. The mine has a single fuze well located in one end of the body. It is fuzed with an electrical detonator which is activated by current from batteries or a hand-held generator

CHARACTERISTICS

Type	Antipersonnel
Color	Gray
Maximum diameter	5 in
Length	9 in
Total weight	12 lb
Filler	Melinite/TNT



PINEAPPLE FRAGMENTATION MINE

Dud Shell Mine

GENERAL DESCRIPTION AND COMMENT

The dud shell mine is improvised from a dud artillery or mortar projectile. The mine is made by removing the fuze from a projectile and drilling a hole into the explosive for an electrical detonator. Batteries or a hand-held generator supply the current to activate the detonator remotely. The mine is usually found along roads or trails. Its effectiveness against armored vehicles and personnel varies with the type and size of projectile used.

CHARACTERISTICS

Type	Antipersonnel/
Color	Varies antivehicular
Maximum diameter	Varies
Length	Varies
Total weight	Varies
Filler	Usually TNT

DUD SHELL MINE

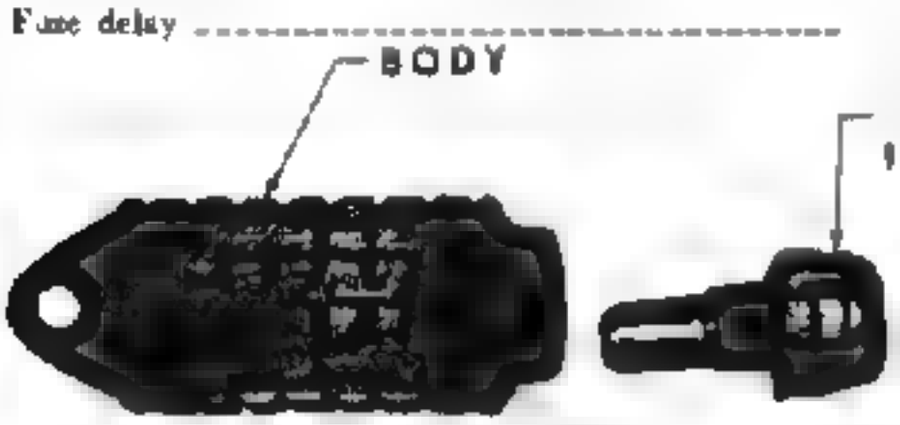
35
Min Antipersonnel Mine

GENERAL DESCRIPTION AND COMMENT

The min antipersonnel mine, made of cast iron, resembles a stick hand grenade with a very short handle. The word, "Min," is often found cast into the body. The handle houses a pull-friction, delay-type fuze. A tug on a tripwire attached to the pull wire of the friction fuze will, by extracting the pull wire, ignite the delay element.

CHARACTERISTICS

Type	Antipersonnel
Color	Gray to black
Maximum diameter	2 in
Length	6.5 in
Total weight	2.2 lb
Filler	TNT
Fuze delay	2 to 4 sec



MIN ANTIPERSONNEL MINE

37
Bounding Fragmentation Mine

GENERAL DESCRIPTION AND COMMENT

The bounding fragmentation mine is improvised from U.S. M2 bounding-mine or M48 trip-flare mine cases. A wooden cylinder slightly smaller in diameter than the mine case is hollowed out so that a standard grenade (frequently the U.S. M26) can fit inside. The wooden cylinder with inclosed grenade is then fitted into the mine case and the grenade's safety pin is extracted. When the mine is initiated electrically, either by a battery pack or a hand generator, the cylinder and grenade are propelled upward. As the wooden cylinder with grenade leaves the case, the handle flies off and initiates the fuze train of the grenade.

CHARACTERISTICS

Type	Antipersonnel
Color	Olive-drab or gray
Maximum diameter	2.5 in
Height	8 in
Total weight	5 lb
Filler	Grenade (TNT)
Fuze delay	3 to 4 sec (grenade)

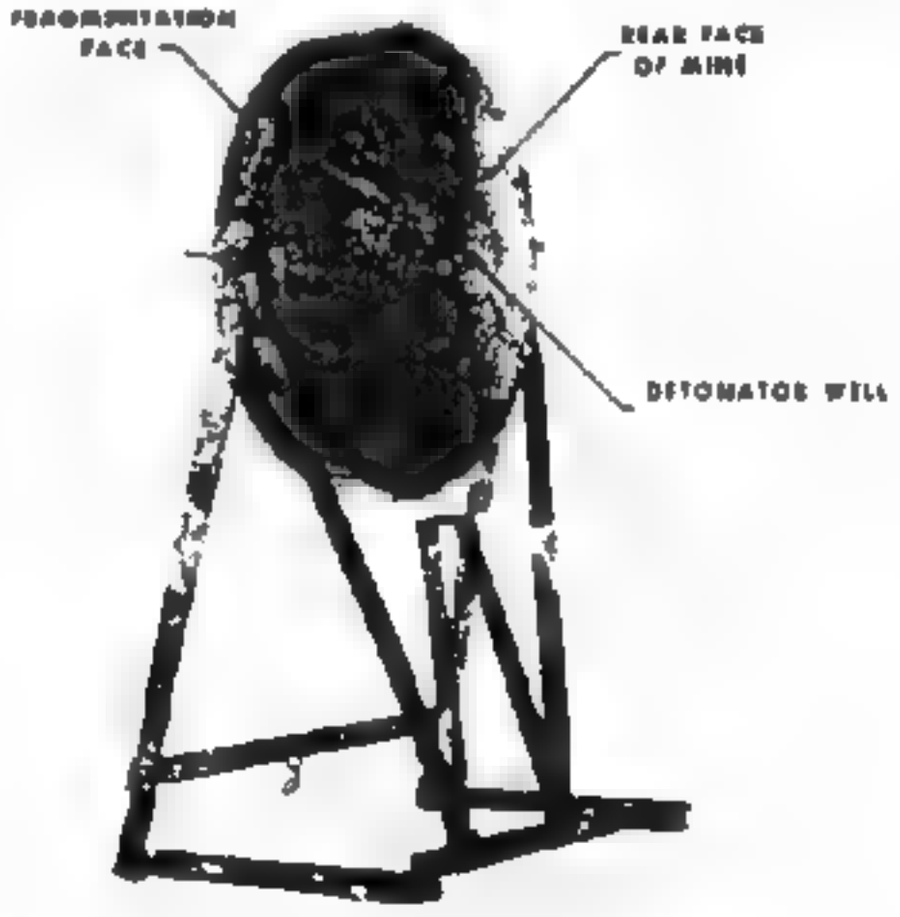
DB-10 Directional Mine

GENERAL DESCRIPTION AND COMMENT

The DB-10 directional fragmentation mine is primarily an antipersonnel mine which also can be used against thin-skinned vehicles or similar items. The concave front or fragmentation face of the mine contains approximately 450 half-inch steel fragments embedded in a matrix, and is backed up by cast TNT. Designed for electrical detonation, the mine is provided with an adjustable frame so that it can be placed on various types of surfaces and aimed in any direction. The single fuze well is centered on the convex (back) side of the mine.

CHARACTERISTICS

Type	Dual purpose
Color	Gray to black
Maximum diameter	12 in
Width	4 in
Total weight	20 lb
Filler	Cast TNT



DB-10 DIRECTIONAL MINE

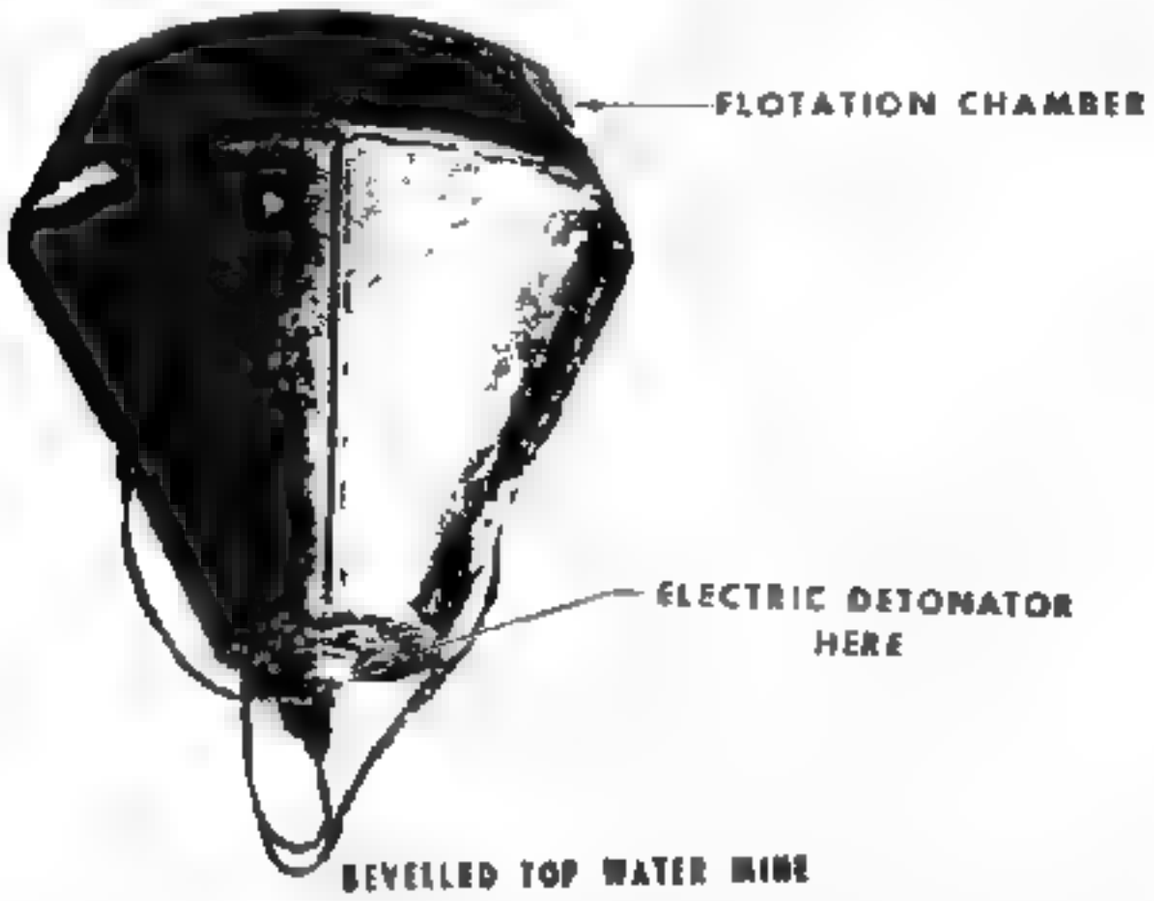
41
Beveled Top Water Mine

GENERAL DESCRIPTION AND COMMENT

Beveled top water mines are found in large quantities in the Mekong River and its tributaries. They are placed at depths compatible with the draft of the boats plying the particular waterway. The mine is constructed of sheet metal rolled into a conical shape, the seams are soldered or riveted. The electrical fuze is located in a fuze well in the bottom of the mine. A flotation chamber is in the end opposite the fuze well. Batteries or a hand-held generator provides the current.

CHARACTERISTICS

Type	Antiboat
Color	Black
Maximum diameter	11 in
Height	12 in
Total weight	27 lb
Filler	TNT



43

Truncated Cone Water Mine

GENERAL DESCRIPTION AND COMMENT

The truncated cone water mine is manufactured from medium-gage sheet metal in two sections riveted together: the explosive section with electrical fuze (small end) and the flotation chamber. When a vessel approaches, the mine is positioned by the Viet Cong on the shore by means of ropes. Once positioned, the mine is detonated by using a battery pack or a hand generator

CHARACTERISTICS

Type	Antitank
Color	Black
Maximum diameter	17 in
Height	25 in
Total weight	83 lb
Filler	TNT

45

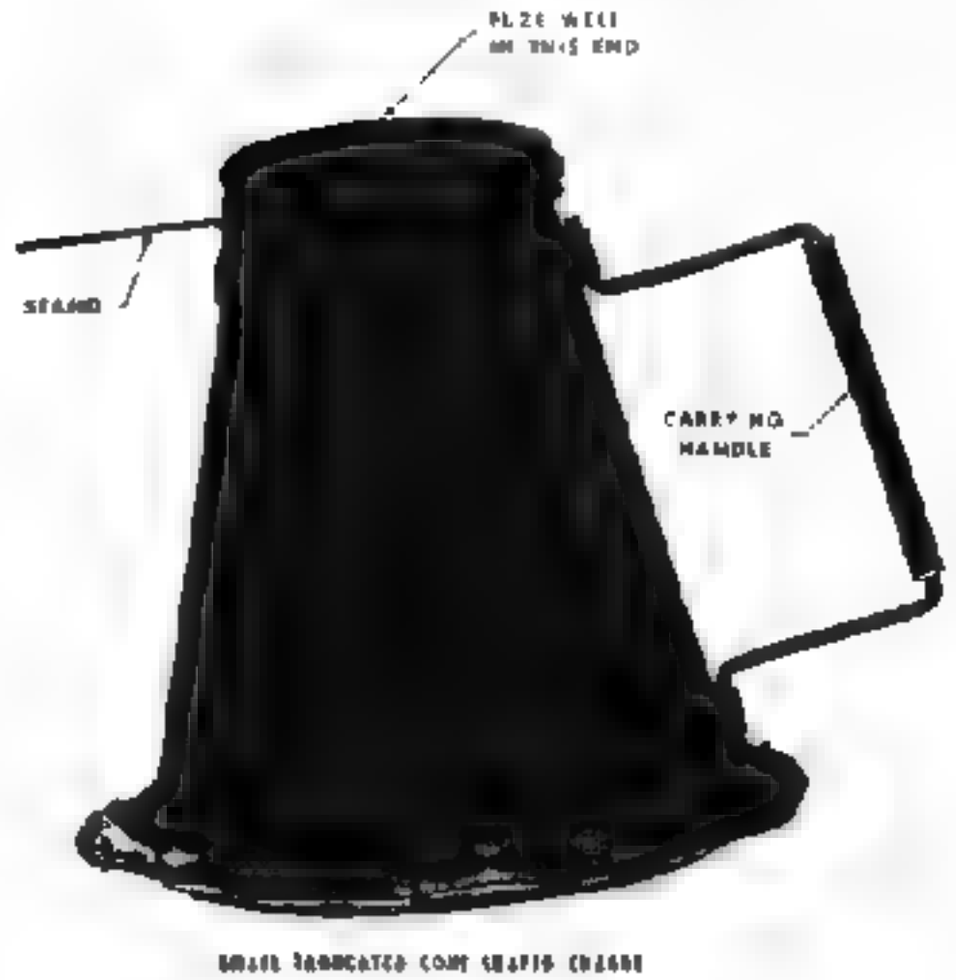
Small Truncated Cone-Shaped Charge

GENERAL DESCRIPTION AND COMMENT

The small truncated cone-shaped charge is encased in sheet metal plates riveted together. A pull-friction fuze in the small end usually initiates the explosive charge; it contains a delay element which allows the Viet Cong saboteur to leave the vicinity before the explosion. Some charges have also been found with electrical detonators and some with boobytraps in the fuze mechanism.

CHARACTERISTICS

Color	Usually black
Maximum diameter	8 to 10 in
Height	8 to 10 in
Total weight	15 to 18 lb
Filler	TNT or homemade explosive
Fuze delay	Approx 9 sec (pull-friction)



47

Large Truncated Cone Shaped Charge

GENERAL DESCRIPTION AND COMMENT

The large truncated cone-shaped charge is encased in heavy-gage sheet metal with welded seams. Its fuze is a pull-release or pull-friction device of unknown construction, which is initiated when a nearby Viet Cong tugs on the pull wire. This charge is also found to be occasionally fuzed for electrical initiation.

CHARACTERISTICS

Color	Unpainted or black
Maximum diameter	9 in
Height	11 in
Total weight	22 lb
Filler	TNT

49

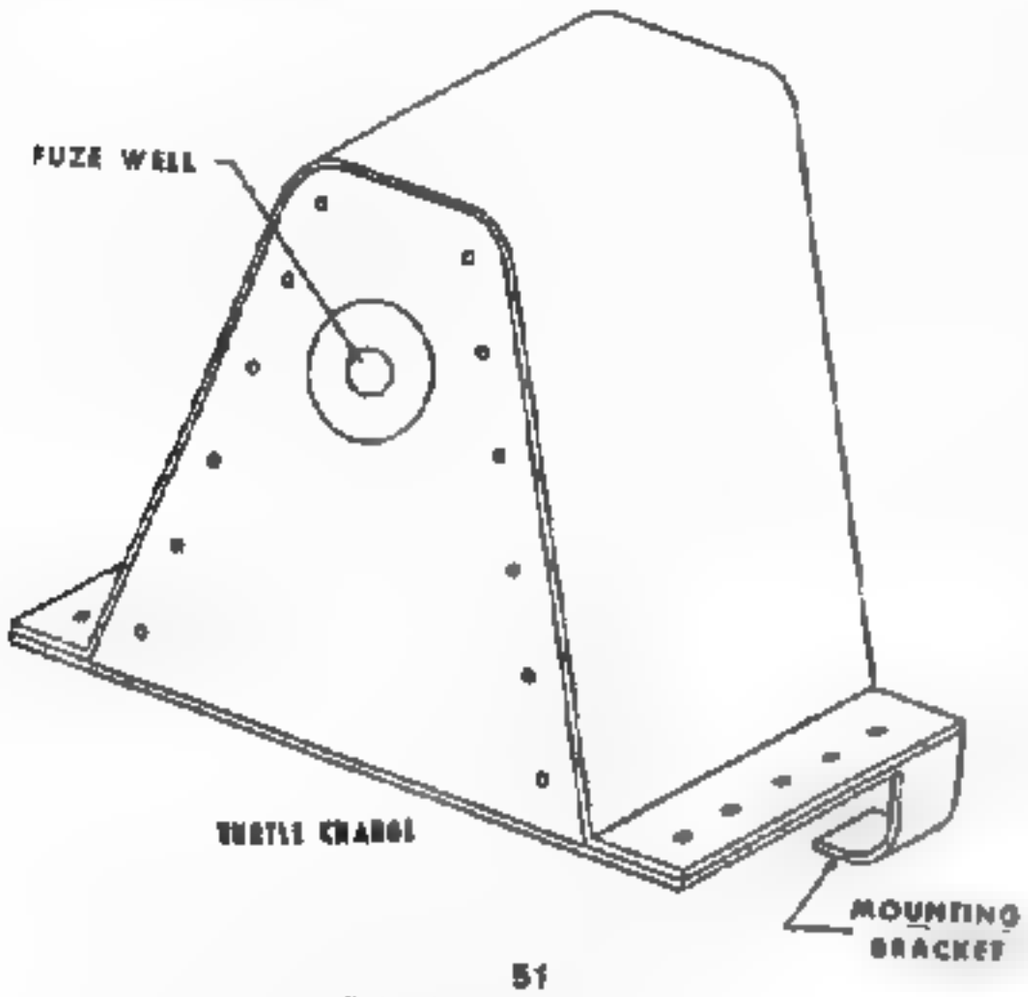
Turtle Charge

GENERAL DESCRIPTION AND COMMENT

The turtle charge is encased in four pieces of sheet metal riveted together and coated with a black waterproofing compound. This charge can be initiated either electrically or mechanically (with or without a delay element). Either type of fuze would be located in the fuze well on the side of the charge and would be initiated by a nearby Viet Cong.

CHARACTERISTICS

Color	Black
Length	Approx 4 in
Width	9 in
Height	5 to 6 in
Total weight	[redacted]
Filler	Picric acid (melinite) or TNT



51
Cylindrical Charge

GENERAL DESCRIPTION AND COMMENT

The cylindrical charge, although normally encased in sheet metal as illustrated, can also be made from artillery and mortar projectile shipping containers. The dimensions and weight vary considerably. The charge is normally fired electrically by a nearby Viet Cong using batteries or a hand-held generator. The weapon could also be fired by pull-friction, mechanical, or delay-type firing devices.

CHARACTERISTICS

Color	Varies
Maximum diameter	Varies
Length	Varies
Total weight	5 to 25 lb
Filler	TNT, potassium chlorate, or homemade explosive

53
Pole Charge

GENERAL DESCRIPTION AND COMMENT

The pole charge consists of a quantity of explosive wrapped in waterproof material such as a piece of tarpaulin or canvas, and lashed to a 3- or 4-foot-long pole. The explosive is initiated by a piece of time fuze crimped to a nonelectric detonator. Pole charges are generally used during assaults for destroying barbed wire entanglements and bunkers.

CHARACTERISTICS

Color	Varies
Maximum diameter	Varies
Length (pole)	3 to 4 ft
Total weight	8 to 15 lb
Filler	Normally potassium chlorate
Fuze delay	Varies

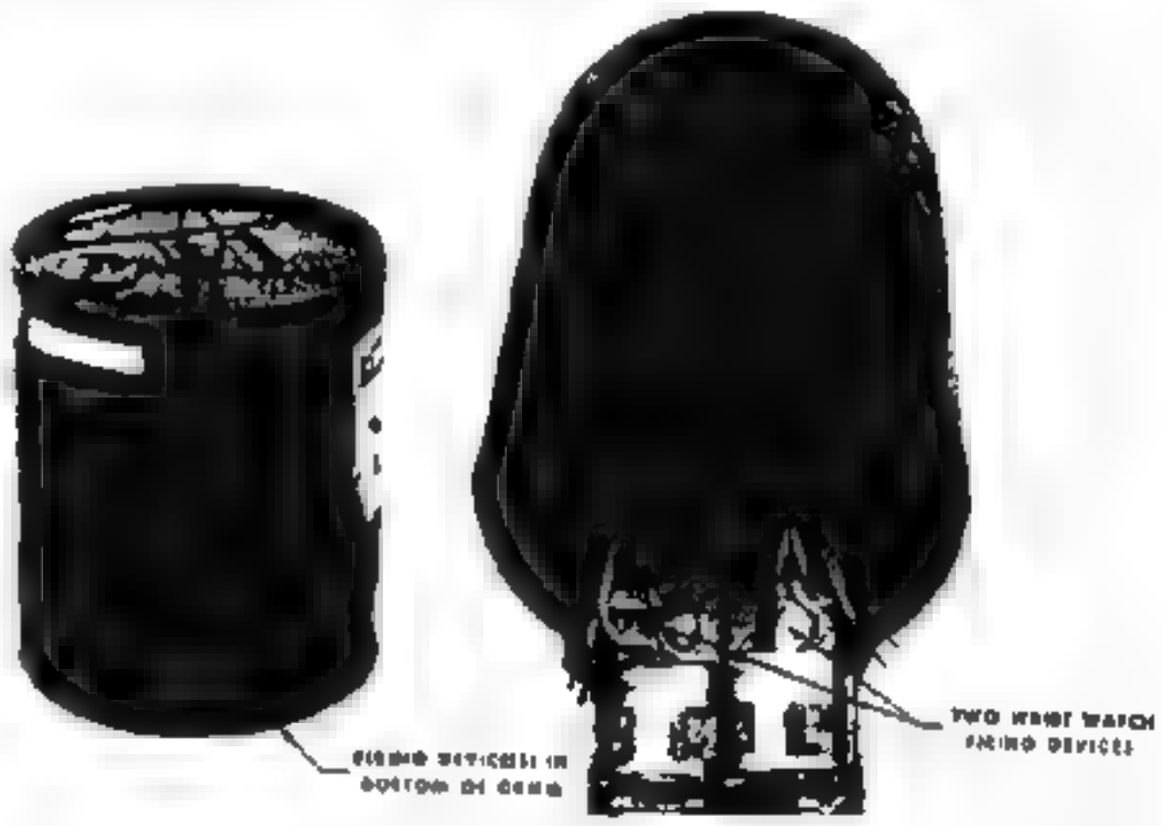
Oil Drum Charge

GENERAL DESCRIPTION AND COMMENT

The oil drum charge is made by partially filling a standard U.S. 5-gallon oil or lubricant drum with explosive and installing a wristwatch firing device (see page 63) in the bottom end. The specimen shown on the opposite page actually has two firing devices to insure that the charge will explode even if one fuze malfunctions.

CHARACTERISTICS

Color	Olive-drab
Maximum diameter	11 in
Height	13 in
Total weight	Approx 25 lb
Filler	Varies



ON OPPOSITE PAGE

57
Bangalore Torpedo

GENERAL DESCRIPTION AND COMMENT

The Bangalore torpedo is generally made from a length of 2-inch-diameter pipe filled with explosive and initiated by a fuze. The specimen illustrated is one of the better made items and has a fuze well in one end. The most commonly encountered Bangalore torpedoes are much cruder in appearance. They may be found with any type of fuze.

CHARACTERISTICS

Color	Black or olive-drab
Maximum diameter	2 in
Length	Approx 42 in
Total weight	Varies
Filler	TNT or picric acid

BANGALORE TORPEDO

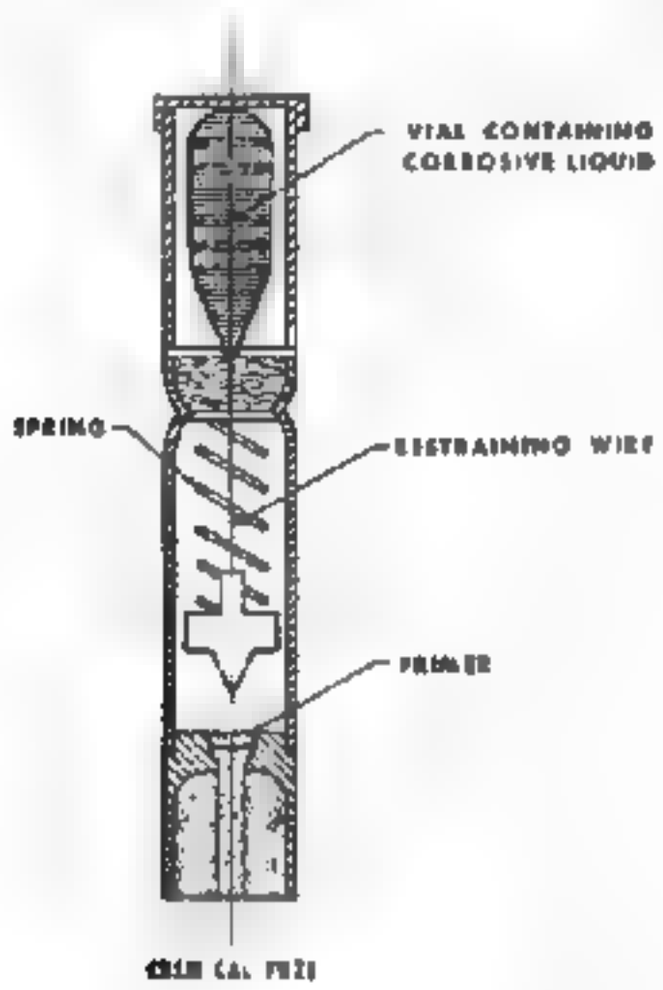
59
Chemical Fuze

GENERAL DESCRIPTION AND COMMENT

The chemical fuze is used for sabotage. It can be attached to any mine or demolition charge. The fuze is initiated by breaking the corrosive liquid vial; the corrosive solution then gradually corrodes the wire which restrains the firing pin. When the wire has weakened sufficiently, the firing pin is released and strikes the primer, detonating the charge. The delay time provided by this fuze varies with temperature and wire diameter.

CHARACTERISTICS

Type	Delay
Diameter	0.5 in
Length	5 in
Fuze delay	Varies; 20 to 38 min



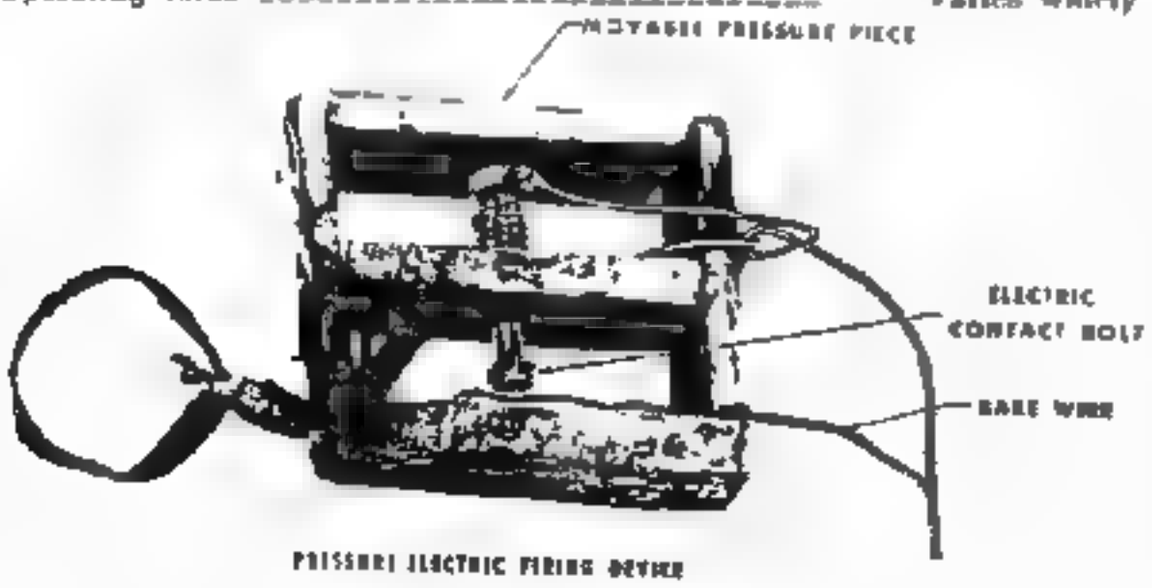
61
Pressure-Electric Firing Device

GENERAL DESCRIPTION AND COMMENT

The pressure-electric firing device consists of a wood frame; a movable, spring-loaded wooden pressure piece attached to a bolt; and a length of double-strand electric wire. One strand of electric wire is attached to the bolt, the second strand (bare) is fastened to the frame. When some outside force (i.e. a person stepping on the device) pushes the pressure piece down so that the head of the bolt contacts the bare strand of wire, the circuit is completed through the electrical detonator which then fires the device.

CHARACTERISTICS

Type	Nondelay
Length	Approx 4.5 in
Width	Approx 1.5 in
Height	Approx 4 in
Operating force	Varies widely

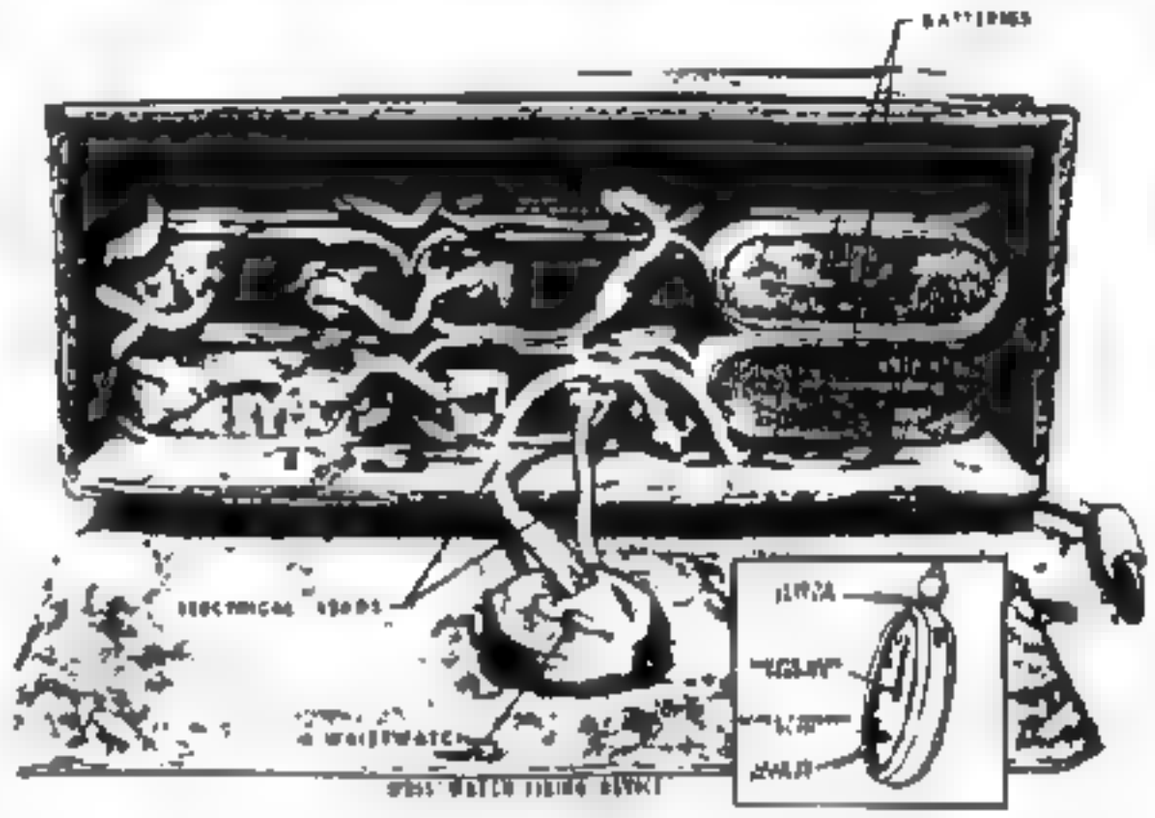


PRESSURE ELECTRIC FIRING DEVICE

62
Wristwatch Firing Device

GENERAL DESCRIPTION AND COMMENT

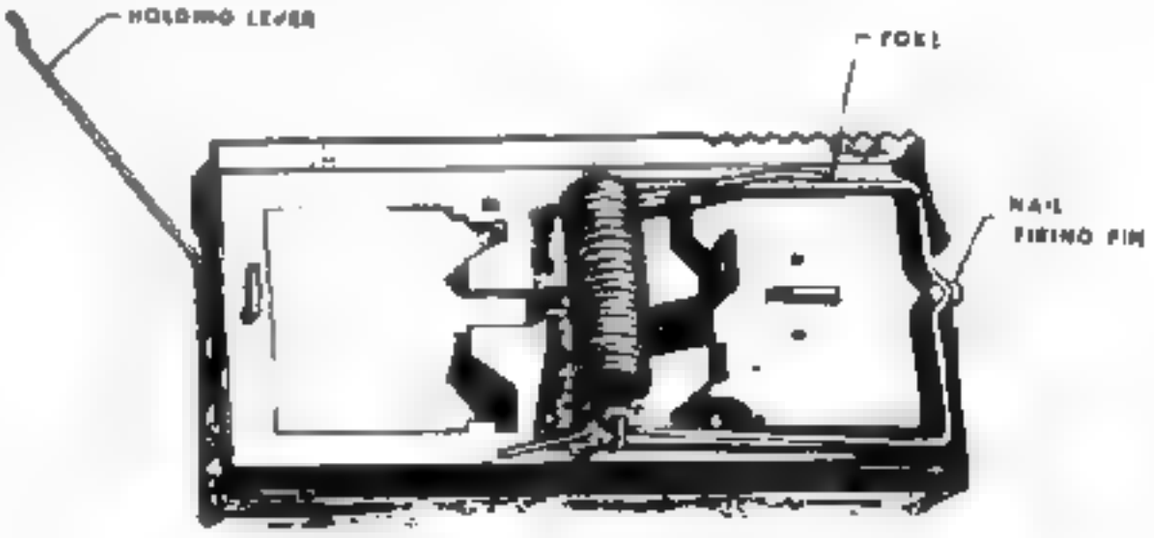
The wristwatch firing device is used to provide a delay between the time an explosive charge (bomb or mine) is placed and the time it explodes. The delay period can range from a few minutes to 12 hours according to how the watch is altered and set. Either the minute hand (if the desired delay is in hours) or the hour hand (if the desired delay is in minutes) is broken off. One electric lead is connected to the stem or case of the watch and the second lead is connected to a screw passing through a hole in the watch crystal. The watch runs for a preset interval until its remaining hand touches the screw; at that time the circuit is completed and an electrical detonator explodes. The illustration shows an actual installation including the power supply; the inset shows a watch only, in schematic form.



65
Mousetrap Firing Device

GENERAL DESCRIPTION AND COMMENT

The mousetrap firing device, as its name indicates, consists of an ordinary mousetrap, arranged so that the yoke, when tripped, will drive a firing pin (nail) into a percussion primer. This firing device has been frequently used on Viet Cong improvised guns. Its future use will probably be confined to boobytrap or antipersonnel mine installations.

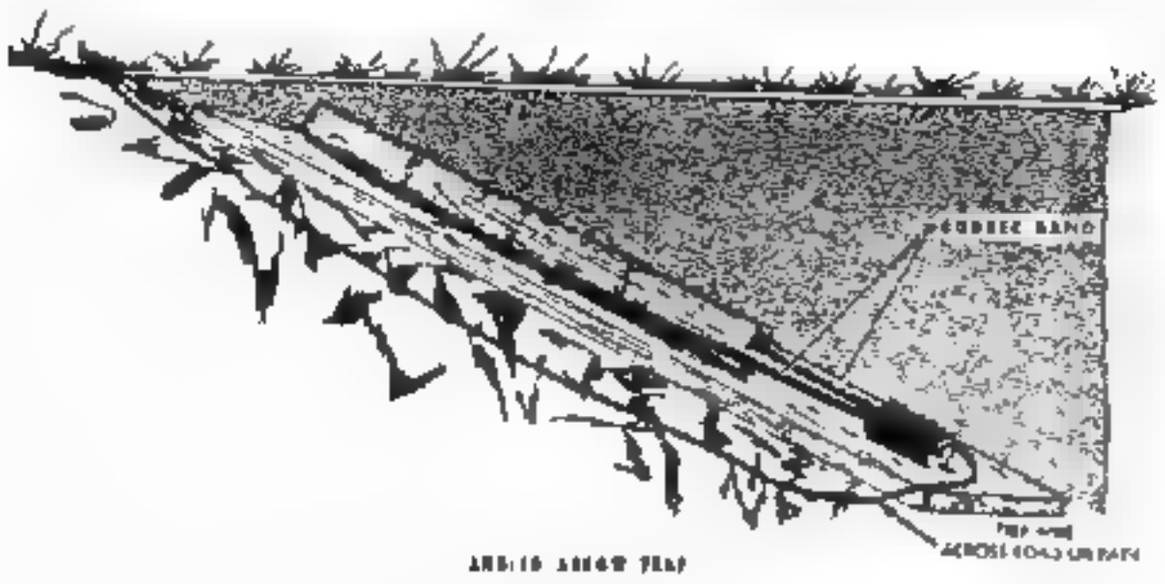


MOUSETRAP FIRING DEVICE

67
Angled Arrow Trap

GENERAL DESCRIPTION AND COMMENT

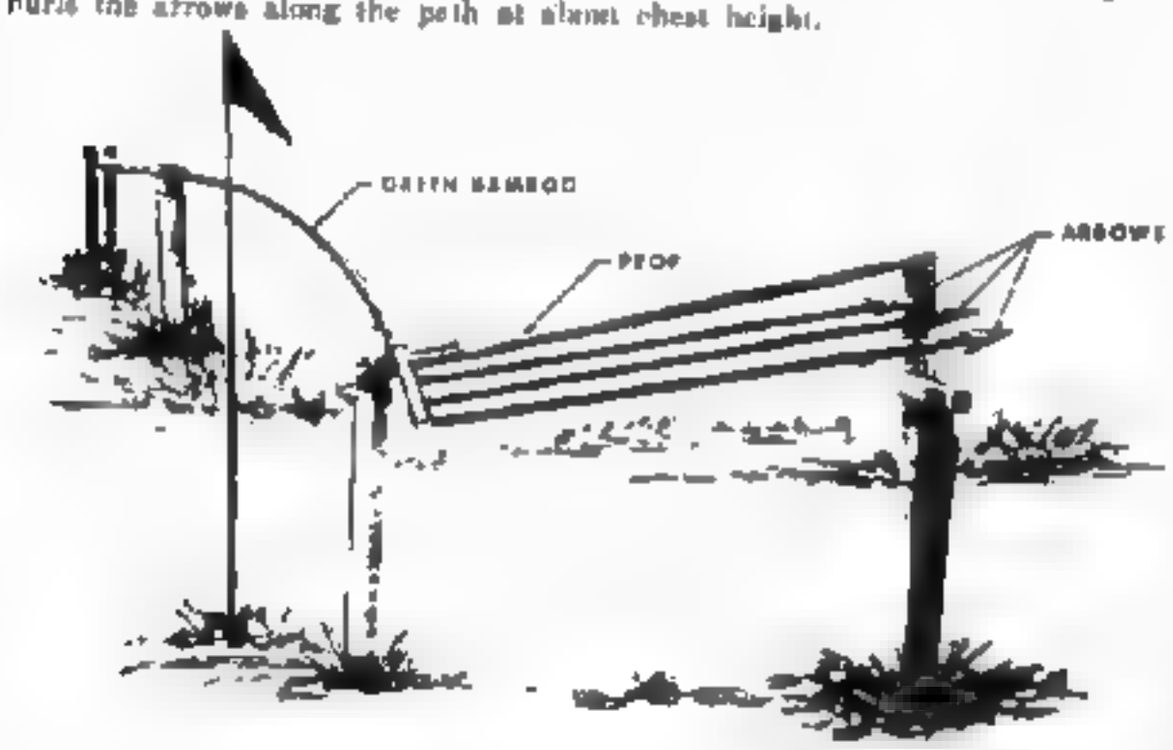
The angled arrow trap is made of a piece of bamboo (about 1-meter long) fastened to a board, a steel arrow, a strong rubber band, a trip-wire, and a catch mechanism. The device is placed in a camouflaged pit, the bottom of which is sloped in such a way that a person tripping the wire will be struck in the thorax by the arrow.



69
Whip

GENERAL DESCRIPTION AND COMMENT

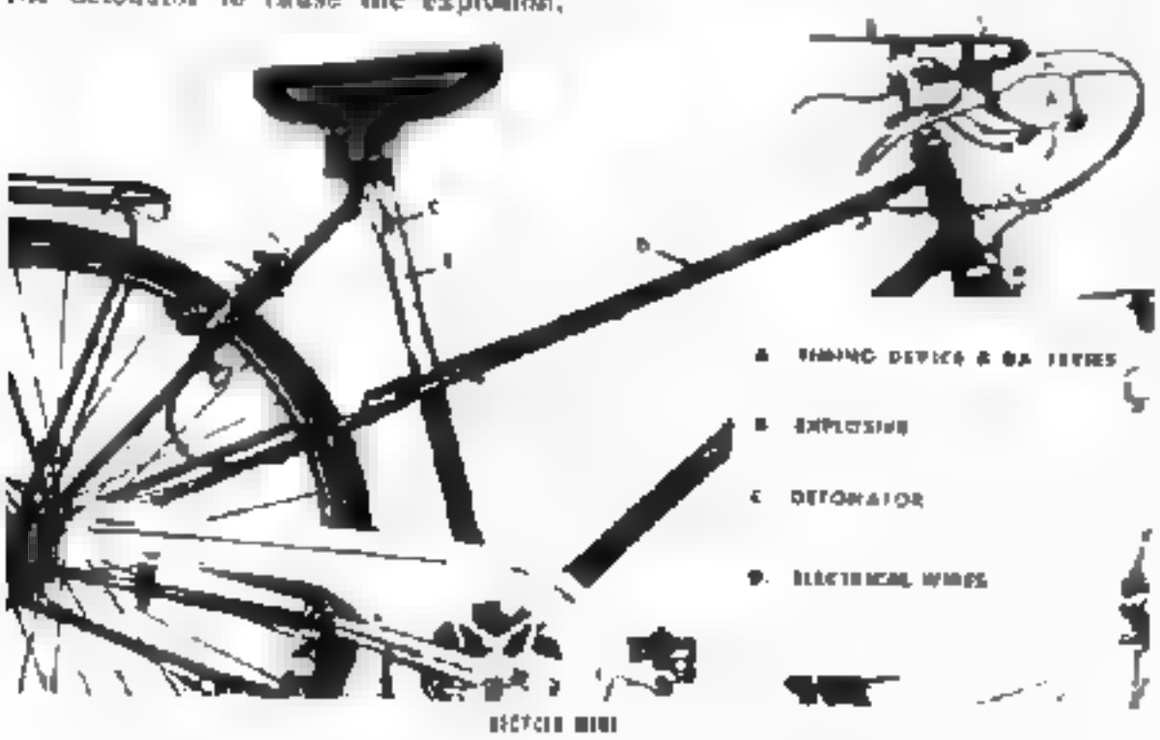
The whip consists of a length of green bamboo, supported by a series of posts, and three or four barbed-point arrows. The bamboo pole is bent and held in an arc position by a catch device. When a tripwire placed across a trail or path is pulled, it releases the catch device, and the bamboo pole hurls the arrows along the path at about chest height.



WHIP
71
Bicycle Mine

GENERAL DESCRIPTION AND COMMENT

The bicycle mine is made from an ordinary bicycle by filling part of the tubular frame with explosive, installing an electrical detonator in the explosive, and connecting the detonator to batteries and a wristwatch firing device (see page 63) in the headlight housing. The bicycle explodes when, after a preset time interval, the wristwatch hand touches an electric contact and the circuit through the detonator is completed. This mine can be varied by connecting the detonator directly to the headlamp power generator; when the bicycle is moved, the generator sends an electric current through the detonator to cause the explosion.

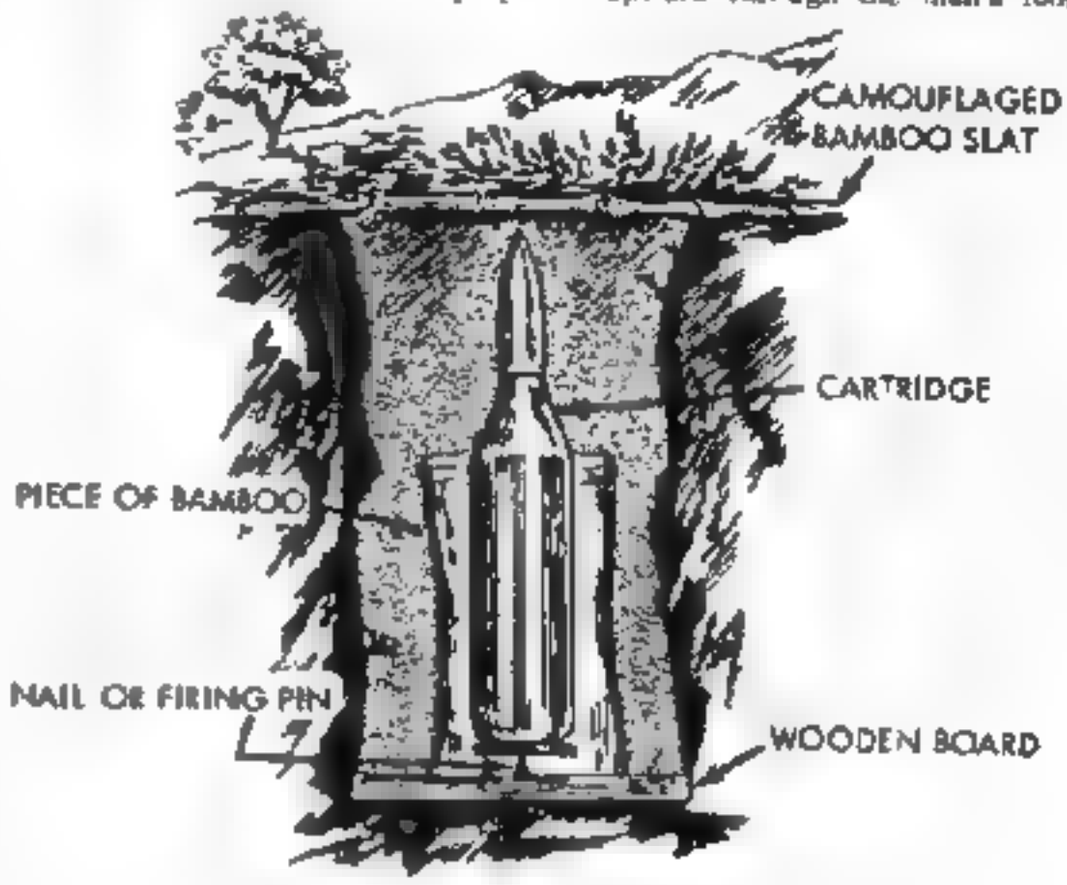


BICYCLE MINE

Cartridge Trap (Foot Breaker)

GENERAL DESCRIPTION AND COMMENT

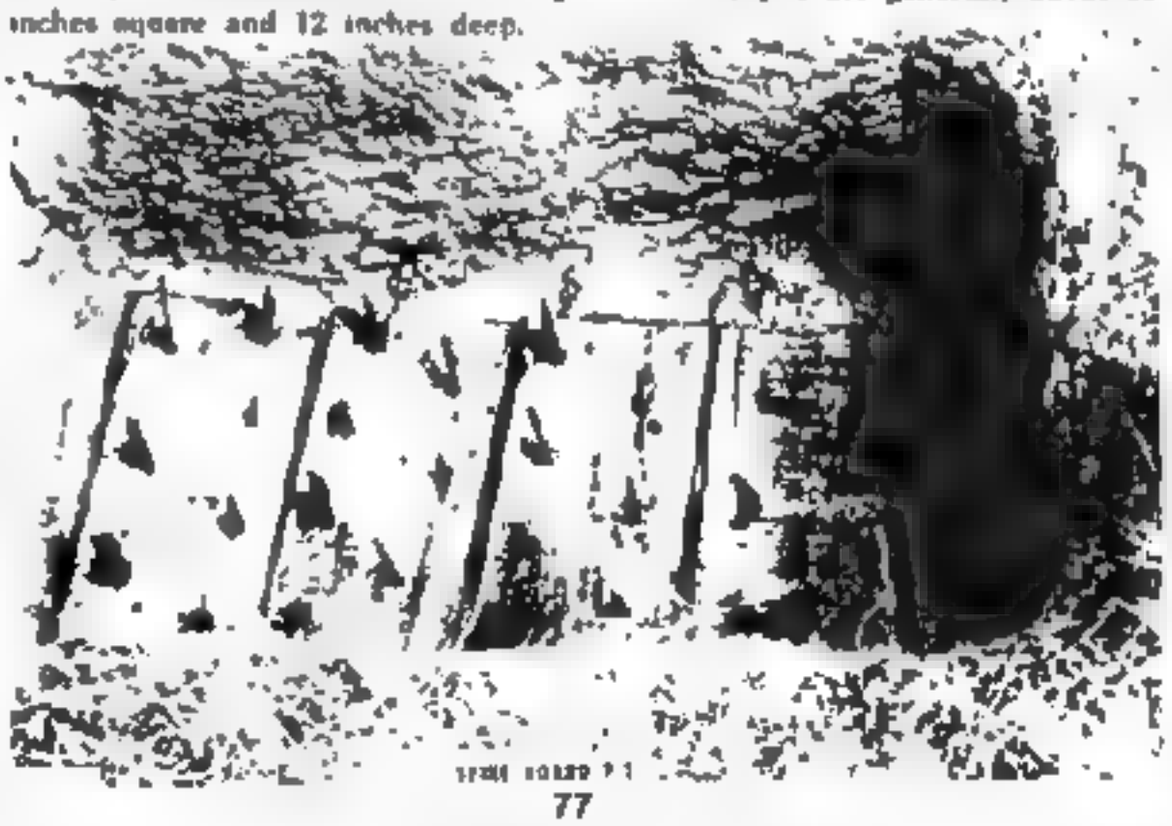
The cartridge trap consists of a cartridge set into a piece of bamboo fastened to a board and installed in a camouflaged pit. A nail driven through the bottom of the bamboo serves as a firing pin. The weight of a man stepping on the upper end of the cartridge forces the nail into the cartridge to initiate the primer; the bullet is then propelled upward through the man's foot.



CARTRIDGE TRAP (FOOT BREAKER)
75
Spike Board Pit

GENERAL DESCRIPTION AND COMMENT

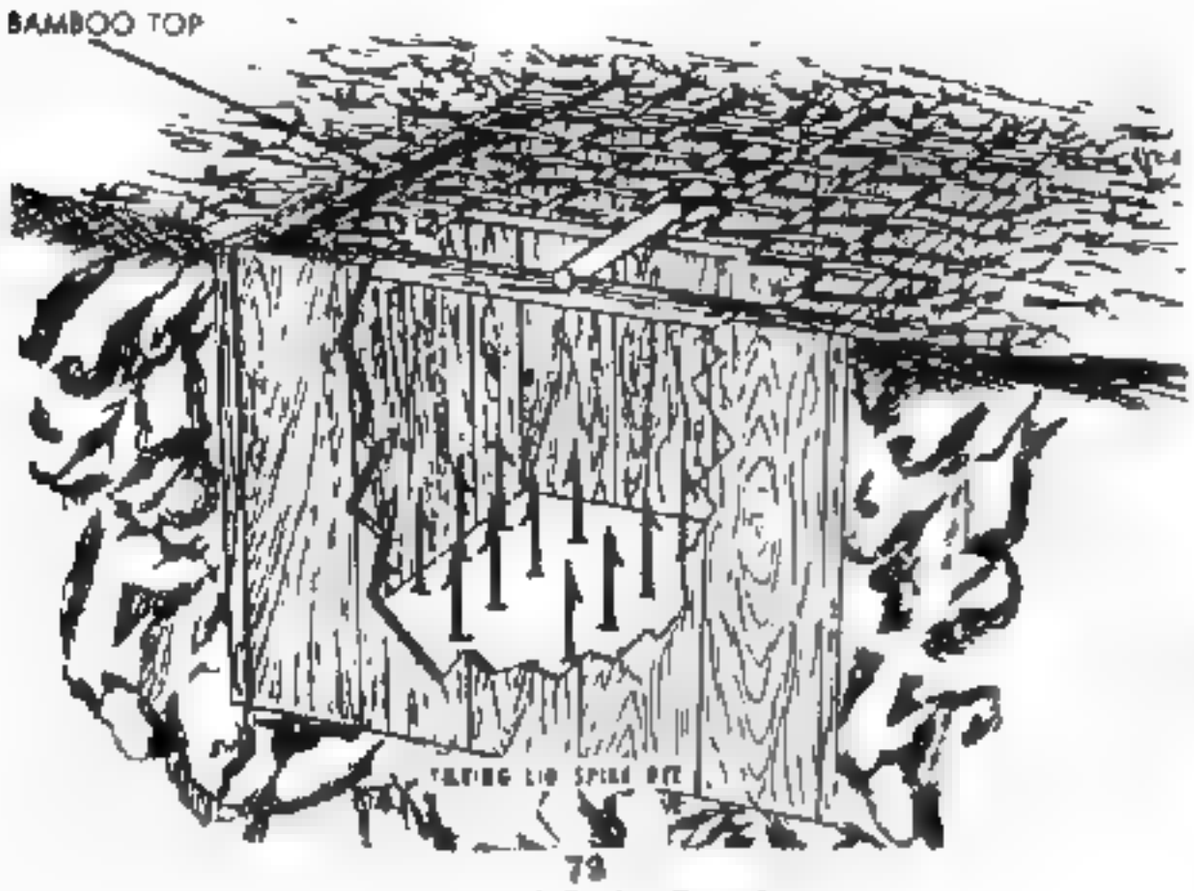
The spike board pit is simply a small pit the bottom of which is lined with boards through which spikes have been driven. The top of the pit is camouflaged. A person stepping on the camouflage material falls into the pit and impales his foot or feet on the spikes. These pits are generally about 18 inches square and 12 inches deep.



SPIKE BOARD PIT
77
Tilting Lid Spike Pit

GENERAL DESCRIPTION AND COMMENT

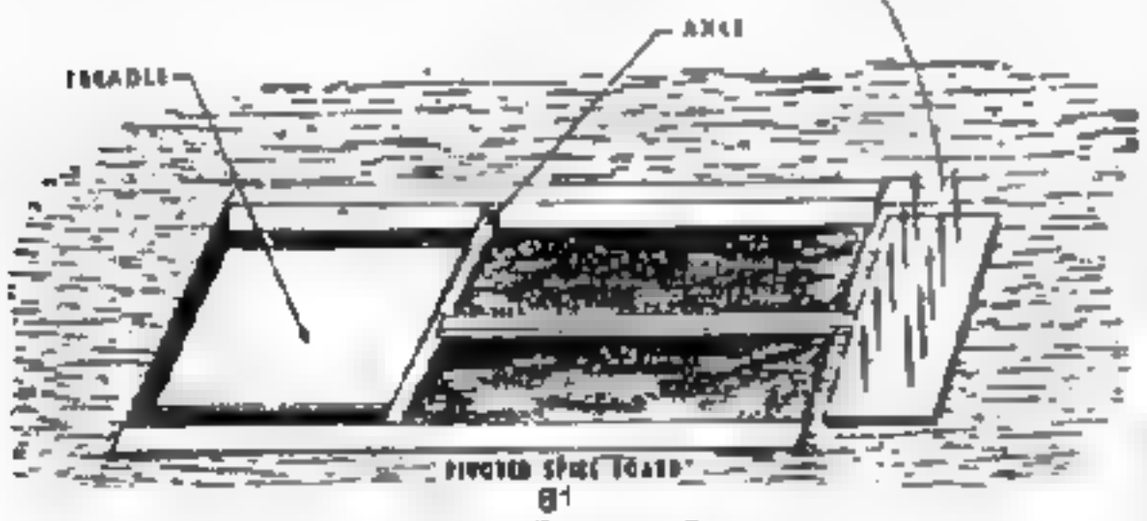
The tilting lid pit is substantially the same type of trap as the spike board pit described on page 75. The major differences are that it is much larger (about 13 feet square by 8 feet deep) and has a pivoting lid. The lid is supported in the middle by an axle; when locked in position it is strong enough to support a man's weight. When the lid is not locked, it pivots when a man steps on it and the man drops into the pit onto the boards with spikes that cover the bottom. The lid, which is counterbalanced, then swings back to its original position. Because of the pit's depth, the walls are shored up with boards or logs to prevent caving.



78
Pivoted Spike Board

GENERAL DESCRIPTION AND COMMENT

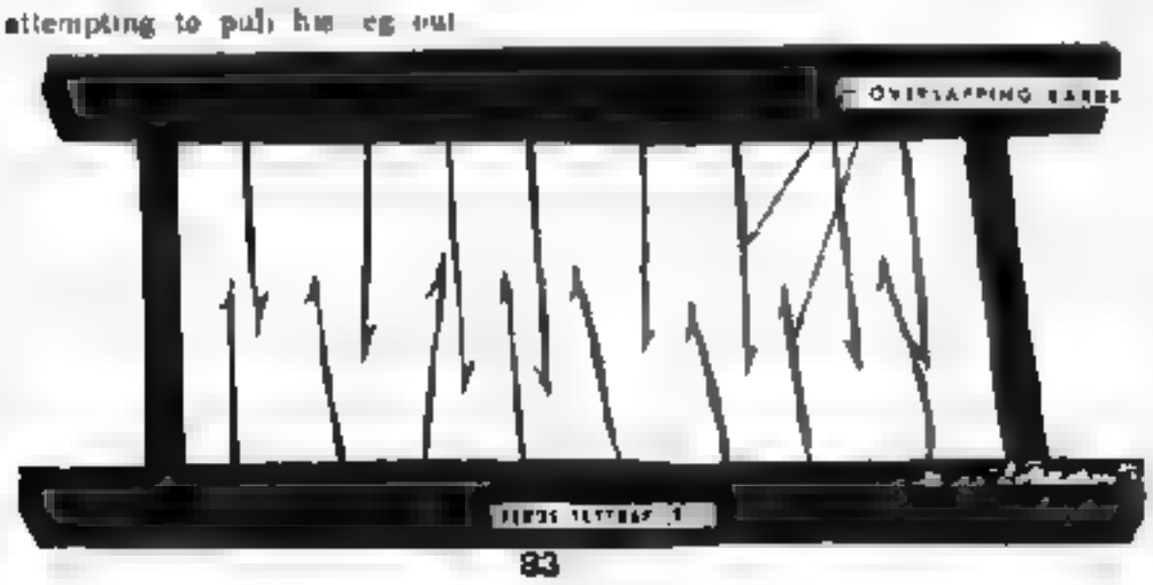
The pivoted spike board is used with a foot pit. When a person steps on the treadle (shown in the illustration), the board with driven spikes pivots about an axle. As the victim drops into the pit, the spike board strikes him in the chest or face.



81
Venus Flytrap (Pit)

GENERAL DESCRIPTION AND COMMENT

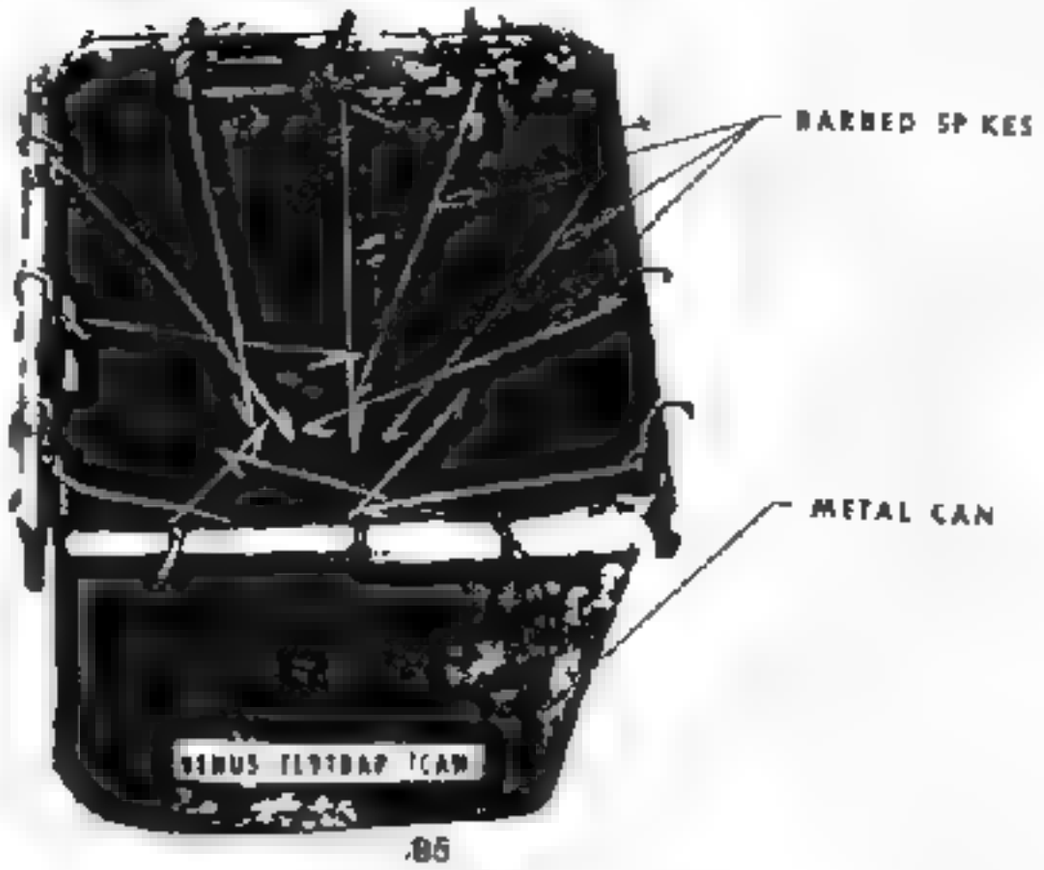
The Venus flytrap (pit) consists of a rectangular framework with overlapping barbs emplaced over a pit on trails or in rice paddies. The dimensions of such devices vary; the one illustrated is approximately 8 by 22 inches. The barbs are angled downward toward the pit, thus making any attempt to extract a leg exceedingly difficult. If a person steps into one of these flytraps, he should cautiously bend the barbs down or cut them before attempting to pull his leg out.



83
Venus Flytrap (Can)

GENERAL DESCRIPTION AND COMMENT

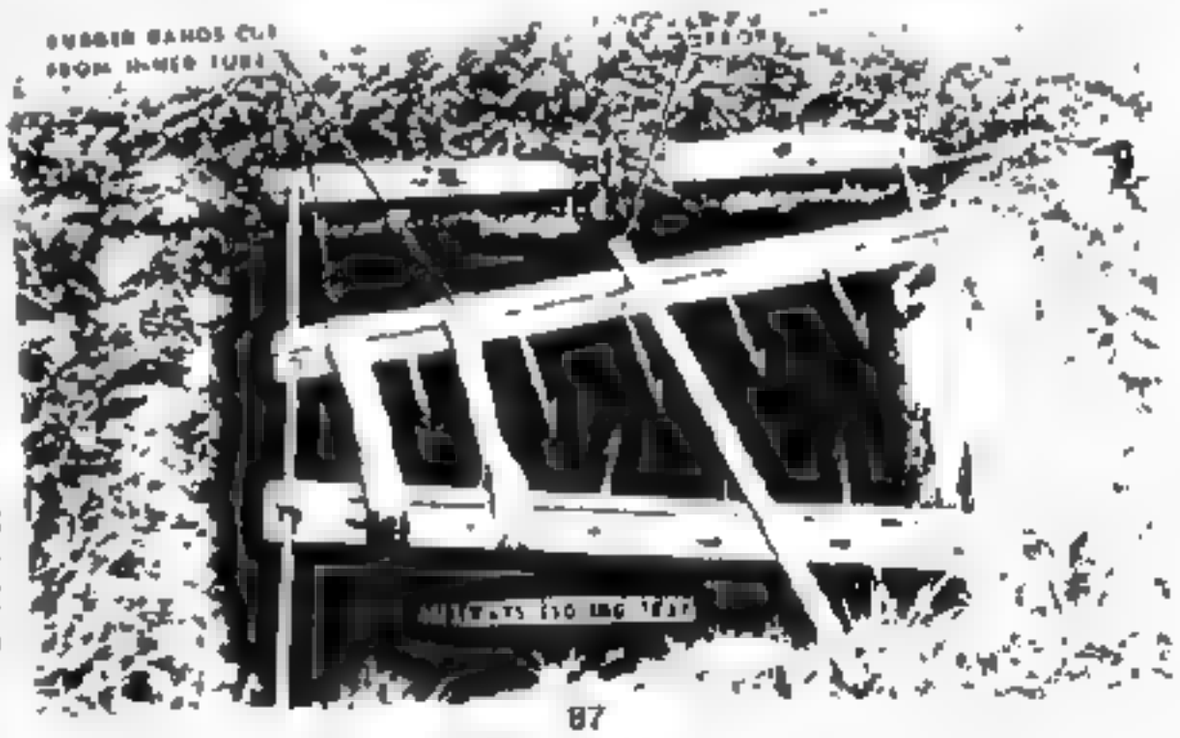
The Venus flytrap (can) is a variation of the Venus flytrap (pit) described on page 81. The flytrap illustrated is constructed of a metal container. An individual trapped in one of these devices should cut off or bend the barbs downward before making any attempt to withdraw his leg.



85
Sideways Closing Trap

GENERAL DESCRIPTION AND COMMENT

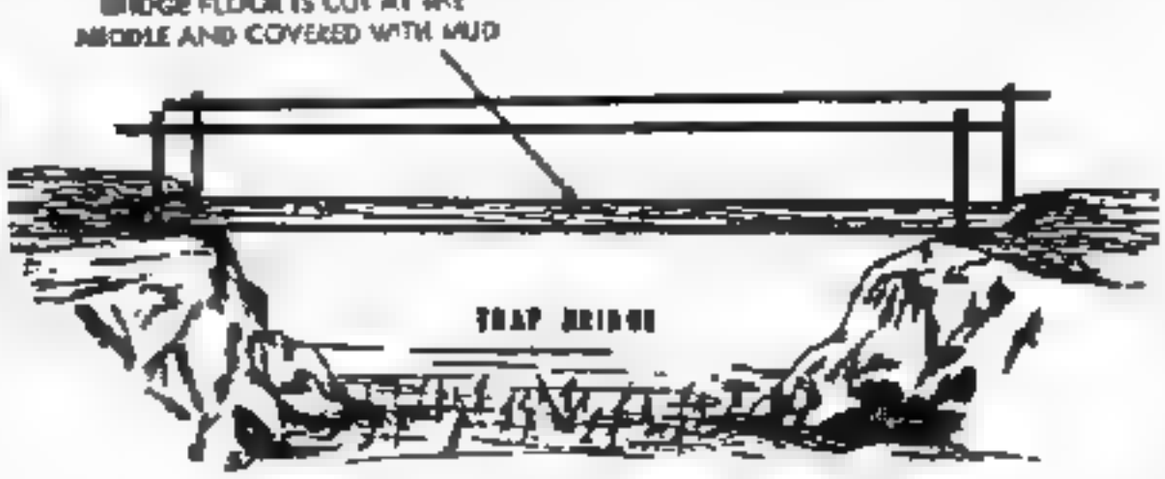
The sideways closing trap, another variety of the spike trap, consists of two wood strips, each studded with barbed spikes, sliding along a pair of guide rods and sprung together by two large rubber bands cut from an automobile inner tube. A wooden prop keeps the spike-studded wood strips apart and stretches the rubber bands. The device is placed in the top of a pit (about 6 feet deep) and camouflaged. As a man steps on this device, he dislodges the prop, whereupon the rubber bands, no longer stretched taut, clamp the spike strips around him. The spikes take his legs, abdomen, and chest until he stops falling. A variation of this device consists of a length of green bamboo split lengthwise, instead of wood strips, with spikes along each side of the split.



87
Trap Bridge

GENERAL DESCRIPTION AND COMMENT

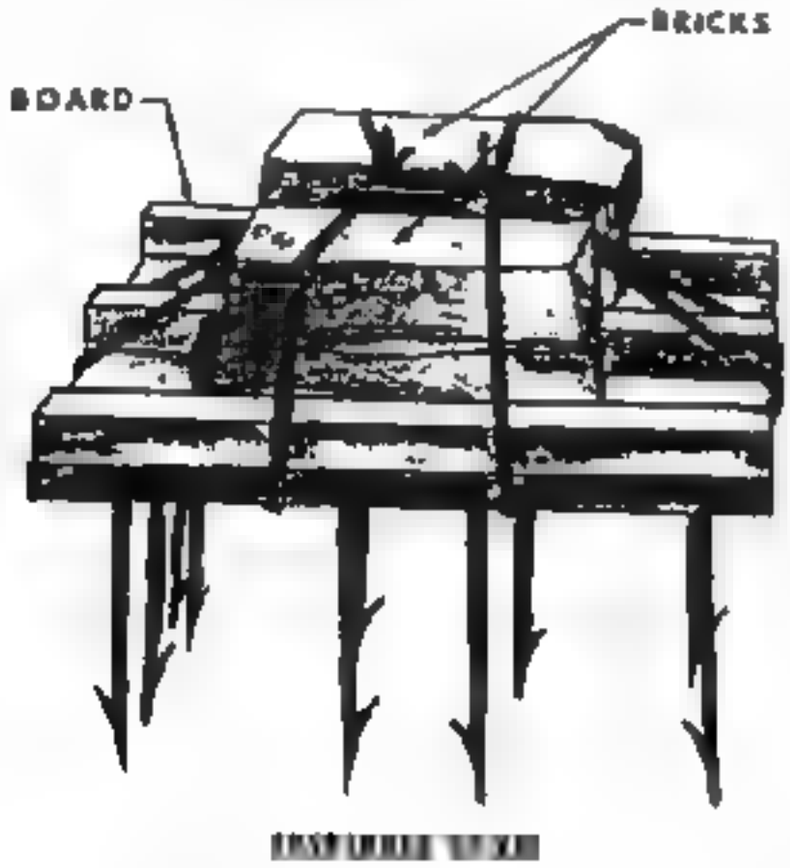
The trap bridge is a wooden bridge booby trapped by partially sawing through the planks and camouflaging the cut with mud. Barbed stakes are laid underneath the bridge and along the adjacent banks. Anyone crossing the bridge causes it to collapse and he or they will be impaled on these spikes.



Suspended Spikes

GENERAL DESCRIPTION AND COMMENT

The suspended spikes device, also known as the Tiger Trap, consists of an 18-inch-square board with spikes. It is weighted with bricks and suspended from the branch of a tree overhanging a path. A tripwire stretched across the path beneath the spike board, when pulled, frees the device to fall on someone below.



Spike Log (Mace)

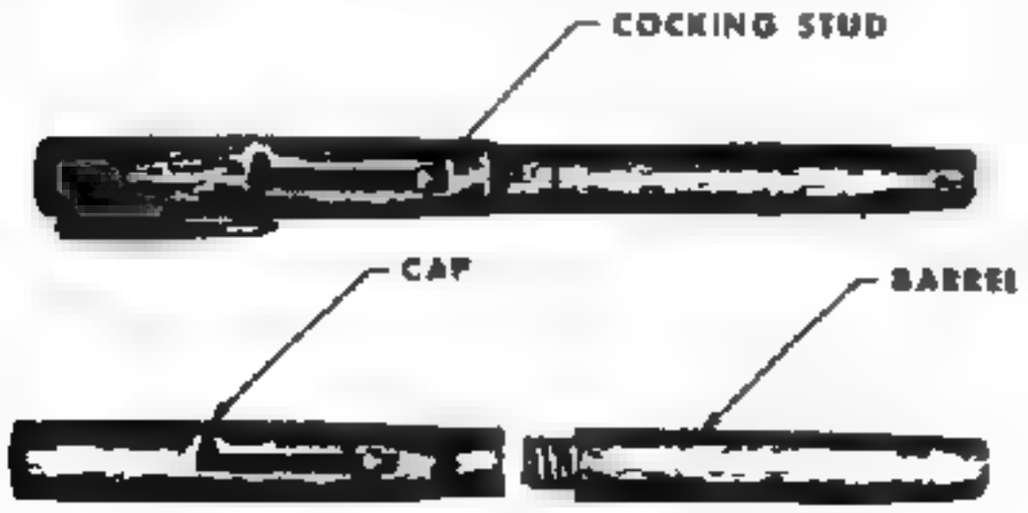
GENERAL DESCRIPTION AND COMMENT

The spike log is approximately 8 to 10 feet long and studded with spikes. It is often left in roadside ditches where it is hidden in the grass. In another emplacement, called the Mace, the spike log is suspended from a tree branch in such a way that, when a tripwire is pulled, the log swings down along the path or trail—impaling anyone in its way.

Cal. 22 Fountain Pen

GENERAL DESCRIPTION AND COMMENT

The caliber .22 fountain pen is actually a weapon which fires a .22-caliber rimfire cartridge. It is used by Viet Cong agents for assassinations. The illustration shows the pen in the uncocked position. When the device is cocked, the round stud (part of the firing pin) will be located in the notch at the left end of the slot in the cap. If the stud is pushed out of the notch, a compressed spring will drive the firing pin into the cartridge, causing it to fire. This device can be varied as a cigarette lighter.



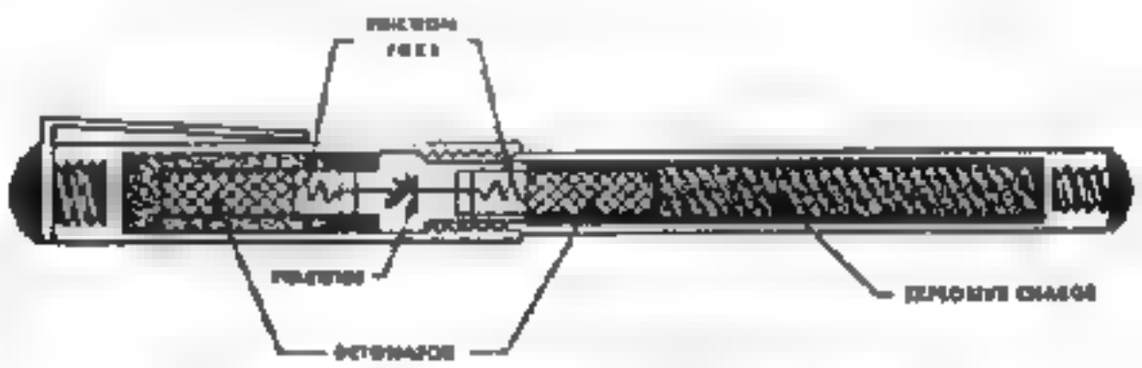
CAL. .22 FOUNTAIN PEN

95

Explosive Fountain Pen

GENERAL DESCRIPTION AND COMMENT

The explosive fountain pen is another type of boobytrap or harassing device. When the cap is unscrewed and removed from the barrel of the pen, two friction fuses function and both cap and barrel explode in the hands of the person holding the pen.



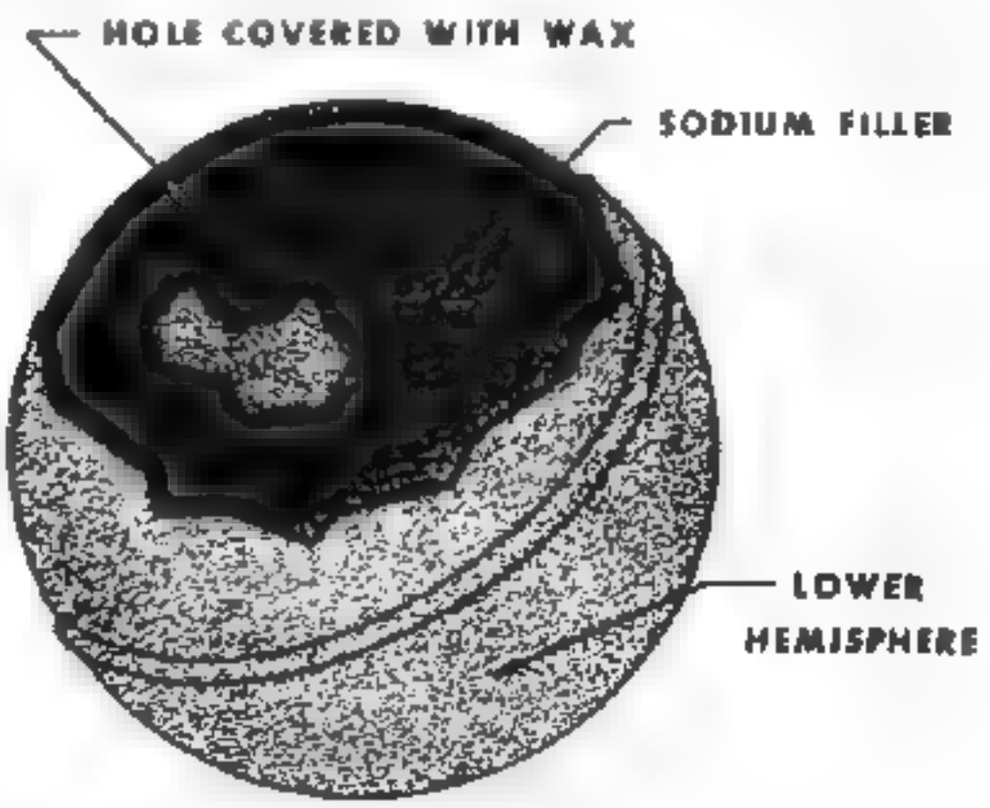
Sodium Incendiary Device

GENERAL DESCRIPTION AND COMMENT

The sodium incendiary device is constructed of two sheet metal hemispheres welded together and containing sodium suspended in a tar-like substance. The body has two holes in its outer surface. A wax and paper covering over the holes waterproofs the item when in storage. When the device is emplaced, the wax cover is removed, allowing water to contact the sodium and thereby creating heat and flame. This device is often emplaced in boat bilges and is particularly effective in any area with oil or gas seepage.

CHARACTERISTICS

Type	Incendiary
Color	Black
Diameter	1.5 in
Weight	1.5 oz
Filler	Sodium



SODIUM INCENDIARY DEVICE

SPECIAL FORCES

HANDBOOK

ST 31—180

JANUARY 1965

THE SPECIAL FORCES HANDBOOK

This handbook contains useful information for the special forces man and is designed to assist you in the performance of your duties.

The material contained herein reflects doctrine as currently taught at the Special Warfare School and is derived from material intended for School use, prepared for resident instruction at the Special Warfare School.

Suggestions and recommendations for changes or corrections should be submitted directly to the Commandant, U.S. Army Special Warfare School, Fort Bragg, North Carolina, ATTENTION: Director of Instruction.

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CHAPTER 1

GENERAL

I. MISSION OF SPECIAL FORCES:

a. To plan and conduct unconventional warfare operations in areas not under friendly control.

b. To organize, equip, train, and direct indigenous forces in the conduct of guerrilla warfare.

c. To train, advise, and assist indigenous forces in the conduct of counterinsurgency and counterguerrilla operations in support of U.S. cold war objectives.

d. To perform such other special forces missions as may be directed or as may be inherent in or essential to the primary mission of guerrilla warfare.

II. UNCONVENTIONAL WARFARE IS COMPOSED OF THE INTERRELATED FIELDS OF:

a. Guerrilla warfare.

b. Evasion and escape.

c. Subversion against hostile states.

III. MISSIONS OF GUERRILLA FORCES:

a. Primary:

(1) Interdict enemy lines of communication.

(2) Interdict enemy installations and centers of war production, and conduct other offensive operations in support of conventional military operations.

b. Supporting Tasks:

(1) Intelligence.

(2) Psychological warfare.

(3) Evasion and escape.

(4) Subversion against hostile states.

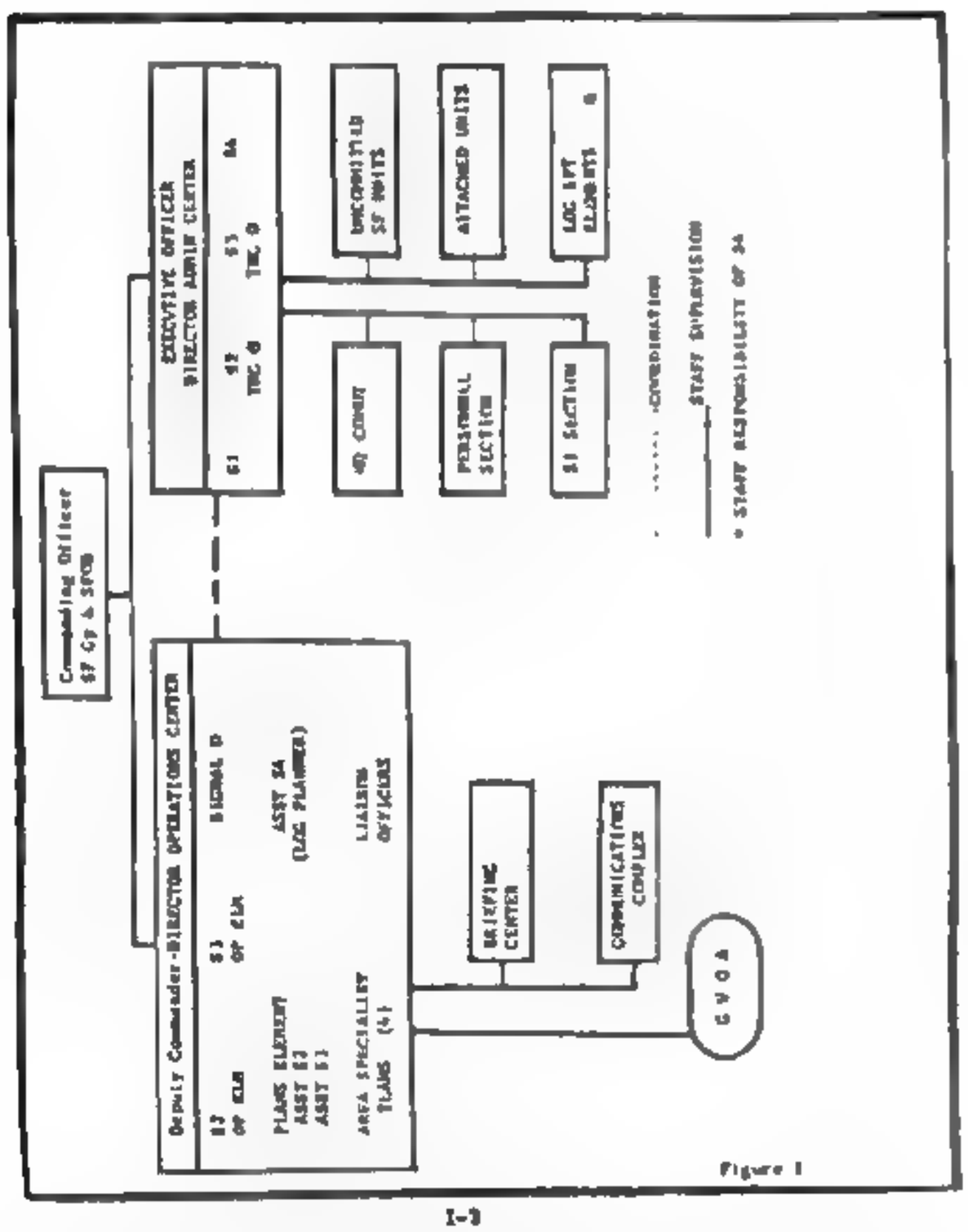

Figure 1

IV. COMPOSITION OF OPERATIONAL DETACHMENTS:

a. Operational Detachment A:

POSITION	RANK/GRADE
CO	Captain
XO	Lt.
OP SGT	E-8
INTEL [redacted]	E-7
LT WPNS LDR	E-7
HV WPNS [redacted]	E-7
MED SP	E-7
ASST. MED SP	E-6
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RAD OP	E-5
DML SGT	E-6
CMBT DML SP	E-5

b. Operational Detachment B:

CO	Major
XO	Captain
SMAJ	E-9
S1	Captain
S2	Captain
S3	Captain
S4	Captain
PREV MED SP	E-7
ADM SUPV	E-6
INTEL SGT	E-8
OP SGT	E-8
SUPPLY SGT	E-7
ASST SUPPLY SGT	E-6
LT WPNS LDR	E-7
HV WPNS LDR	E-7
DML SGT	E-7
CMBT DML	E-5
MEDICAL SP	E-7
RAD OP SUPV	E-7
RAD OPR (4)	E-5

c. Operational Detachment C:

CO	Lt Col
XO	Major
[redacted]	E-9
S1	Captain

S2	Captain
S3	Captain
S4	Captain
ADM SUPV	E-6
INTEL SGT	E-8
OP SGT	E-8
SUPPLY SGT	E-8
ASST SUPPLY SGT	E-7
RAD OP SUPV	E-7
RAD OP (4)	E-5
RAD REPAIRMAN	E-4

CHAPTER 2

TACTICS

ESTIMATE OF THE SITUATION

1. MISSION: Mission assigned and analysis thereof to include sequence of task(s) to be performed and the purpose.

2. SITUATION AND COURSES OF ACTION:

a. Considerations affecting possible courses of action.

(1) Characteristics of the area of operation: weather, terrain, other.

(2) Relative combat power: enemy situation and friendly situation.

b. Enemy capabilities

c. Own courses of action: Who, What, When, Where, Why, and How as appropriate.

3. ANALYSIS:

a. Select enemy capabilities.

b. List advantages and disadvantages.

(1) Course of action vs enemy capabilities.

(2) Course of action vs enemy capabilities.

4. COMPARISON

a. Review and summary of advantages and disadvantages.

b. Determination of significant advantages and disadvantages.

5 RECOMMENDATION/DECISION:

Formal statement of the course of action recommended/adopted.

II-1

[redacted]

Task Organization: Includes the task subdivisions or tactical components comprising the command and reflects the unit of organization for combat.

1. SITUATION:

a. Enemy Forces: situation, capabilities, indications.

b. Friendly Forces: missions and locations of higher adjacent, supporting and reinforcing units.

c. Attachments and Detachments: units attached to or detached from the unit issuing the order, for the operation concerned. Effective time of attachment or detachment is indicated when other than the time of the order.

2. MISSION:

Based on the order of the next higher headquarters and the commander's analysis of his mission, this paragraph contains a clear, concise statement of task(s) to be accomplished by the unit issuing the order and its purpose.

3. EXECUTION:

a. Concept of Operations.

b. Tactical mission of unit.

c. Coordinating Instructions: Tactical instructions and details of coordination applicable to two or more elements of the command.

4. ADMINISTRATION AND LOGISTICS:

Matters concerning supply, transportation, service, labor, medical evacuation and hospitalization, personnel, civil affairs and miscellaneous.

5. COMMAND AND SIGNAL:

a. Signal instructions and information.

b. Command post and location of the commander.

[redacted]

a. Operation overlay.

b. Fire support plan.

DISTRIBUTION:

II-2

II. PATROL LEADER'S ORDER

1. SITUATION:

a. Enemy forces: Weather, terrain, identification, location, activity, strength.

b. Friendly Forces: Mission of next higher unit, location and planned actions of units on right and left, fire support available for patrol, mission and routes of other patrols.

c. Attachments and Detachments.

2. MISSION: **What the patrol is going to accomplish?**

3. EXECUTION: (Subparagraph for each subordinate unit.)

a. Concept of operation.

b. Specific duties of elements, teams, and individuals.

c. Coordinating instructions:

(1) Time of departure and return.

(2) Formation and order of movement.

(3) Route and alternate route of return.

(4) Identification techniques used when departing and reentering the friendly area (s).

(5). Rallying points and action at rallying points.

(6) Location and actions at mission support sites.

(7) Actions on enemy contact.

(8) Actions at danger areas.

(9) Actions at objective.

II-3

(10) Rehearsals and inspections.

(11) Debriefing.

4. ADMINISTRATION AND LOGISTICS:

a. Rations.

b. Arms and ammunition.

c. Uniform and equipment (Note which member will carry and use)

d. Method of handling wounded and prisoners.

5. COMMAND AND SIGNAL:

a. Signal.

(1) Signals to be used within the patrol.

(2) Communication with higher headquarters--radio call signs, primary and alternate frequencies, times to report and special code to be used.

(3) Challenge and password.

b. Command:

(1) Chain of command.

(2) Location of patrol leader and assistant patrol leader information.

III. PATROL WARNING ORDER

The patrol warning order should consist of the following items of information.

a. A brief statement of the enemy and friendly situation.

b. Mission of the patrol.

c. General instructions.

II-4

(1) General and special organization.

(2) Uniform and equipment common to all, to include identification and camouflage measures.

(3) Weapons, ammunition, and equipment each member will carry.

(4) Who will accompany patrol leader on reconnaissance and who will supervise patrol members' preparation during patrol leader's absence.

(5) Instructions for obtaining rations, water, weapons, ammunition and equipment.

(6) The chain of command.

(7) A time schedule for the patrol's guidance. At a minimum, include meal times and the time, place, and uniform for receiving the patrol leader's order.

IV. TROOP LEADING PROCEDURE

1. Begin planning:

a. Study terrain from map, sketch or aerial photo for:

(1) Critical terrain features.

(2) Observation and fields of fire.

(3) Cover and concealment.

(4) Obstacles.

(5) Avenues of approach.

b. Make quick estimate of situation (thorough as time permits).

c. Make preliminary plan.

2. Arrange for:

a. Movement of unit (where, when, how).

b. Reconnaissance (select route, schedule, persons to take along, use of subordinates).

c. Issue of order (notify subordinate leaders of time and place).

d. Coordination (adjacent and supporting units).

3. Make reconnaissance (examine the ground - see 1a above, if necessary changes preliminary plan).

4. Complete plan (receive recommendations, complete estimates, change preliminary plan as necessary, prepare order).

5. Issue order (include orientation on terrain if possible).

6. Supervise.

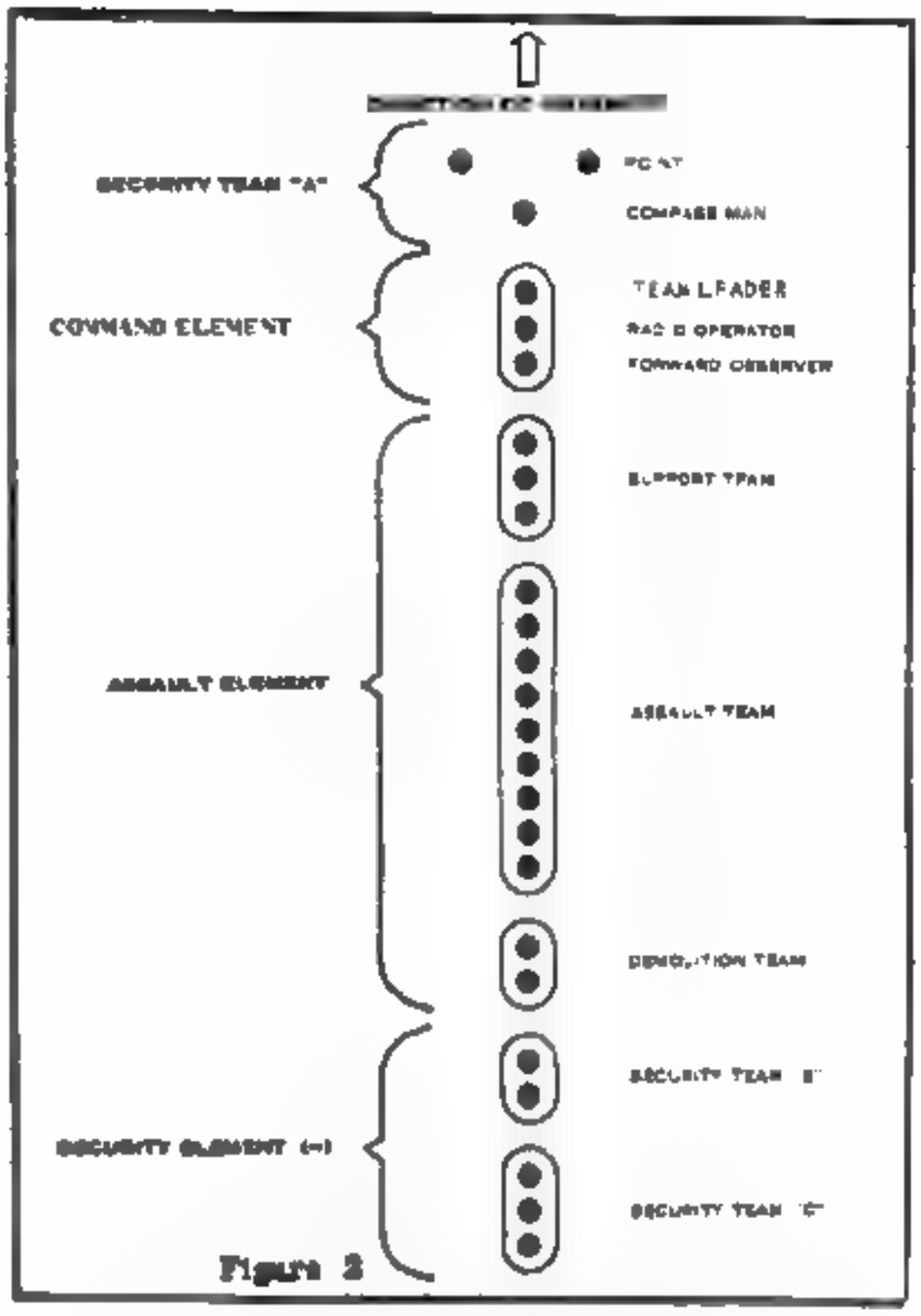


Figure 2

An example of the organization for movement of a raid force.

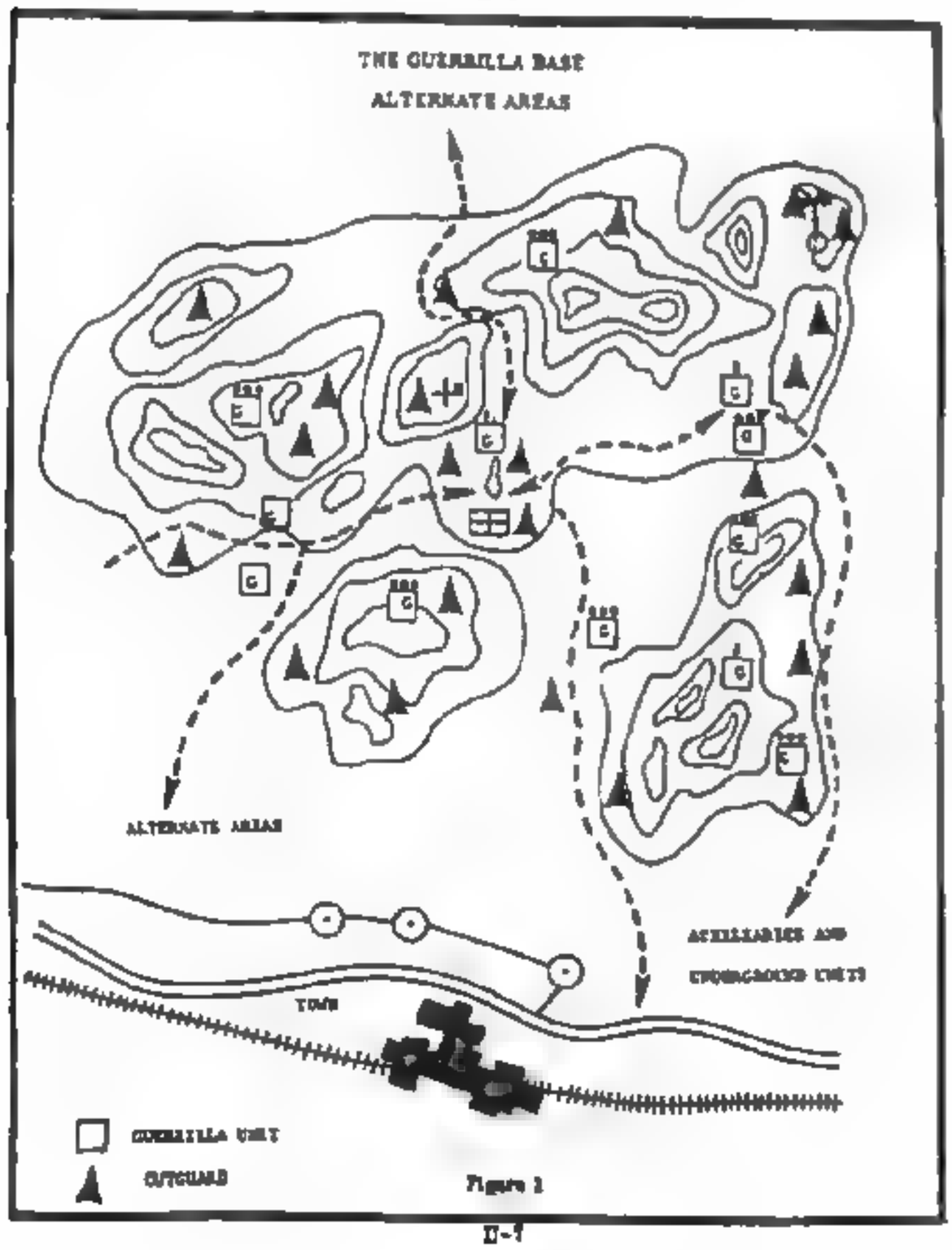


Figure 1

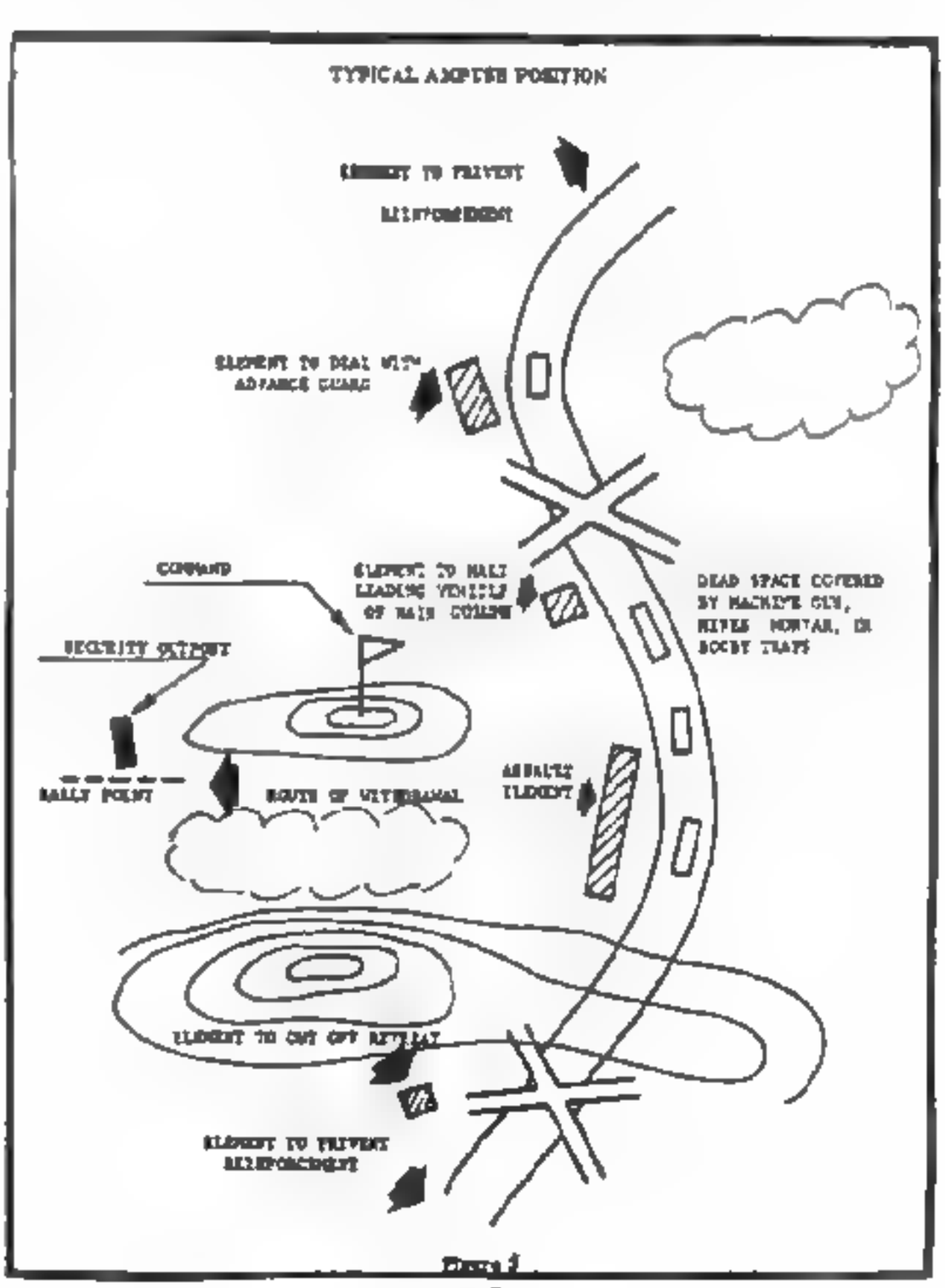


Figure 3

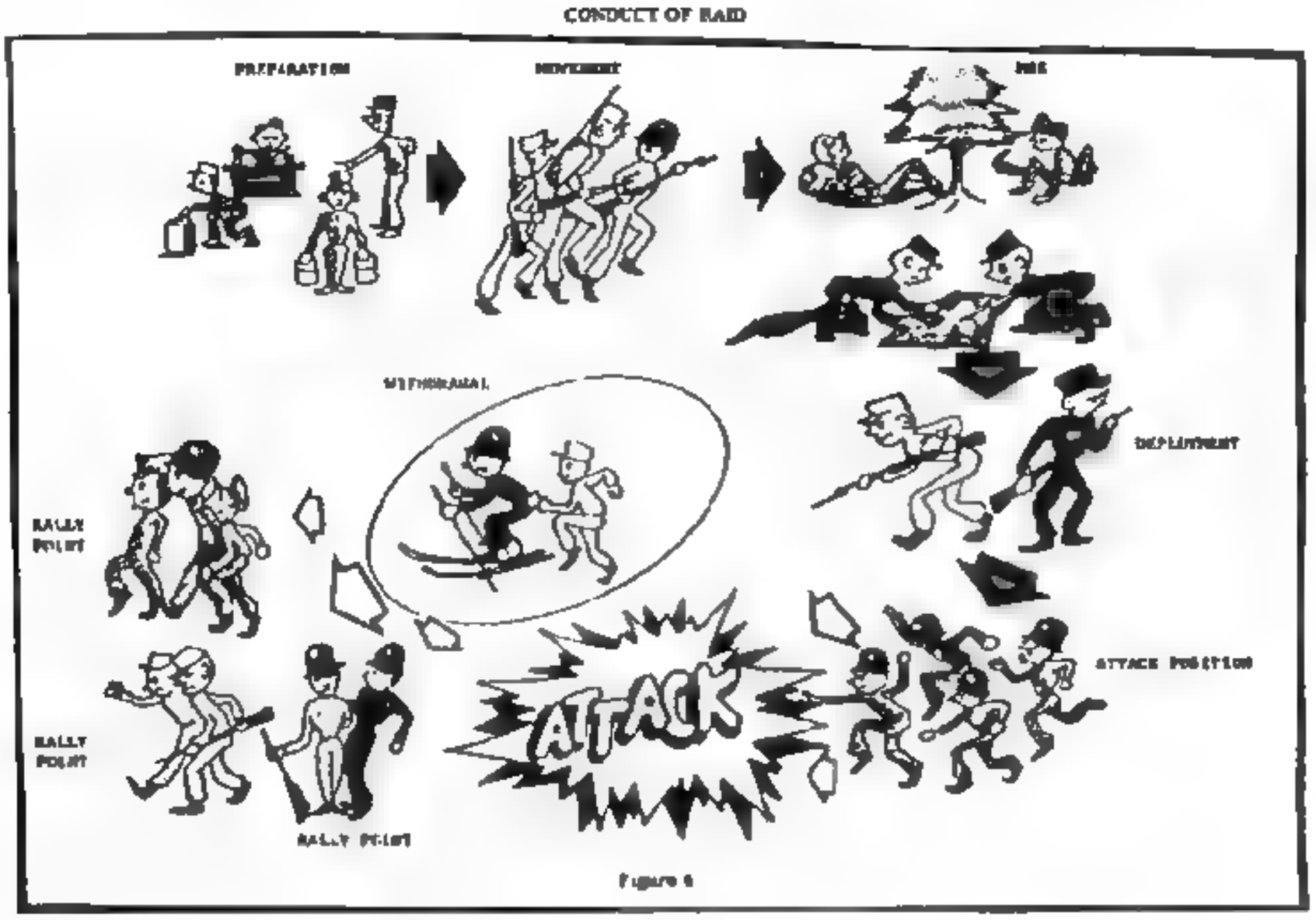


Figure 6

II-19

CHAPTER 3

DEMOLITIONS

1. INTRODUCTION: The following information pertaining to field engineering and demolitions is intended to supplement, but not to replace, that contained in FM 5-25, "Explosives and Demolitions," and FM 5-34 "Engineer Field Data." These field manuals, GTA 5-14, The Demolition Card and GTA 5-21, The Mine Card, are convenient references that should be obtained and used in conjunction with this section of the handbook.

III-1

TABLE I. PRINCIPAL EXPLOSIVES OF THE WORLD

USA	TNT	CYCLONITE *C3-4	TETRYL*TET-RYTOL	PETN *PENTOLITE *PRIMACORD	AMM NITRATE AMATOL
BRITISH	TNT *TROTYL	PLASTIC EX-PLOSIVE OR * PE-2A	COMPOSITION EX OR C.E.	PETN *PENTOLITE *CORD TEX (DETCORD)	*AMMONAL *MONOBEL (AMMT)
FRENCH	TOLITE				NITRATE D'AMMONIUM *TOLITE
GERMAN	PULL PULVER SPRENG MUNG	*CYCLONITE *HEXOGENE *PLASTIC *NITOLIT		*KRALLZUND-SCHURR **	*AMMON SALPETER
ITALIAN	TRITOLO *TRI-TOO	*HYNAGENE *T-6			NITRATE D'AMMONIO *PNP SCHNEIDERITE *TOLUAL AMONAL
JAPANESE	CHA KAT-SUYAKY	KOSHITSUSKUY-AKU *CYCLONITE *O-SHITSUYAKU	MELAYAKU	BIOE-I-YAKU	AMMON YAKU *HONAYAKU *BIOAE *GOKUYAKU
RUSSIAN	TOL *TRYTYL	HEXOGEN *KAMMKITE	TETP	TEN *DSH 1942**	*GROMOBOY *AMMONITE *DINOMANONE *MANITE

*Compounded with other explosives **Not known whether this is demolition explosive or a detonating cord.

III-2

TABLE II. BASIC DEMOLITION FORMULAS

STEEL, STRUCTURAL:

$P = \frac{3A}{8}$ (lb) $K = \frac{1}{24} A$ (cm)

STEEL, RODS, BARS, CABLES (2 inches or less hard carbon steel):

$P = D^2$ (lb) $K = \frac{D^2}{14}$ (cm)

WOOD, EXTERNAL:

$P = D^2$ (lb) $K = \frac{D^2}{550}$ (cm)

WOOD, INTERNAL:

$P = D^2$ (lb) $K = \frac{D^2}{3500}$ (cm)

PRESSURE:

$P = 2R^2T$ (lb)

Metric pressure formula

NOTE: When metric weights and measures are used, substitute breaching formula for the pressure formula.

BREACHING:

$P = R^3KC$ (lb) (Add 10 percent if less than 50 pounds)

$K = 16 R^3KC$ (lb) (Add 10 percent if less than 22.5 KG)

C = Tamping factor for breaching (see demo card)

K = Material factor for breaching

MATERIAL	R IN FEET	R IN METERS	K FACTOR
ORDINARY EARTH	ALL VALUES	ALL VALUES	.05
Poor masonry shale, good timber & earth construction	All values	All values	.25
Good masonry, ordinary concrete, [redacted]	Less than 4	[redacted]	35
	4 to 6	1 to 1.5	.20
	6 to 7	1.5 to 2	.33
	More than 7	More than 2	.36
Reinforced concrete (however will not cut reinforcing steel)	Less than 3	Less than 1	.70
	3 to 5	1 to 1.5	.65
	5 to 7	1.5 to 2	.60

P=Amount of TNT, in pounds, required for an external charge. For relative effectiveness of other external charges, see Table IIA.

III-3

Table IIA *Characteristics of Explosives*

Item	Preparation	Condition rod required for 50 charge	Amount of explosive required for cut	Relative effectiveness as material charge (TNT=1.00)	Availability of item	Remarks
TNT	Main charge booster charge cutting and breaching charge and general use demolition charge	Minimum blasting cap, No. one of equivalent	[illegible]	1.00	Unrestricted	Excellent
Tetryl			[illegible]	[illegible]	Unrestricted	[illegible]
Composition C3			[illegible]	[illegible]	Unrestricted	[illegible]
Composition C4			[illegible]	[illegible]	Limited	Unsurpassed
Ammonium Nitrate Military cratering charge	Cratering and ditching use explosive		[illegible]	0.4	Unrestricted	[illegible]
Military Dynamite M1	Land clearing, cutting and trunk use and general use		[illegible]	[illegible]	Unrestricted	Limited
Straight Dynamite (Commercial) 40%, 20%, 60%	Land clearing, cratering and general use	Non-instantaneous cap, one turn of instantaneous	1½ lbs	[illegible]	N A	Used when water is present
Ammonia Dynamite 40%, 20%, 60% (Commercial)	Land clearing, cratering, ditching and general use in wet areas	Non-instantaneous cap, one turn of instantaneous	[illegible]	[illegible]	Unrestricted	Poor
Gelatin Dynamite 40%, 20%, 60%			[illegible]	[illegible]	Limited	Limited
PETN	Detonating cord	Non-instantaneous cap	[illegible]	N A	Limited	Limited
	Blasting cap	N A	N A	N A	N A	N A
TETRYL	Booster charge	Minimum blasting cap	2 oz	1.2	Unrestricted	Unrestricted
	Blasting cap	N A	N A	N A	N A	N A
Composition B	Demolition charges and shaped charges	Minimum blasting cap, one turn of instantaneous	[illegible]	1.35	Unrestricted	Unlimited
Black Powder	Time fuse	N A	N A	N A	Unrestricted	Poor
HBX	M6 and M7 bursting charge	N A	N A	N A	N A	N A

III-3A

II. RAIL CUTS. While single rail cuts have a harrassing or nuisance value, we will usually be concerned with cuts designed to derail a train. In order to insure the derailment of a modern locomotive it is necessary to remove a length of rail equal to the length of the fixed wheel base of the locomotive. The weight of a locomotive is counterbalanced in such a way that the removal of rail less than the length of the fixed wheelbase may not result in derailment.

a. Twenty-foot gap Technique. World War II experience and related tests have established that a charge sufficient to remove 20 feet of rail will result in positive derailment of a locomotive under most operational situations. The most effective cut is on the outside rail of a curve. Where two or more tracks parallel, derailment should be made in such a manner that a train, when wrecked rounding a curve on the inside track, will obstruct all tracks. When derailment is attempted on a straight stretch of a multiple track line, attack should always be made on an inside rail. Note that in all cases only one of the two rails of a track is attacked.

b. The Derailment Charge requires three quarter pounds of plastic explosive, either C3, C4 or their equivalent, to cut the standard rail (80 lbs. per yard). One-third of the standard issue plastic demolition block is a convenient unit of measure. A series of three, quarter-pound charges is arranged on the web of the rail as diagrammed in figure 1. The series of charges should not bridge a fish-plate. One charge is placed directly over each tie on the selected 20 feet of rail. This will result in removing all rail, at least partially breaking the ties directly under the rail, and creating some minor cratering of the roadbed ballast. Standard center tie spacing is 22 1/2 inches; however, variations run from 18 inches on up to 3 feet. Lacking specific information on the tie spacing, the distance between prepared charges is based on 18 inch measurement which results in placing 16 of the three quarter pound charges for each derailment series on a continuous detonating cord main line. The detonating cord main line to which the individual charges are attached is 23 feet in length to provide approximately a foot tail at either end for quick attachment of a firing system. A triple roll knot for each three quarter pound charge is fixed on the main line as diagrammed in figure 2. These knots are arranged roughly on 18 inch center to coincide with the anticipated tie spacing. They are arranged to insure a snug continuous contact with the main line but loose enough to slide; thus making it possible to make on target adjustments for variations in tie spacing. The individual three quarter pound charges are firmly molded around each triple roll knot. They must be sufficiently wrapped to withstand the necessary rough handling in bringing them on target and to also insure that the charge and knot will slide as an integral unit.

[redacted]

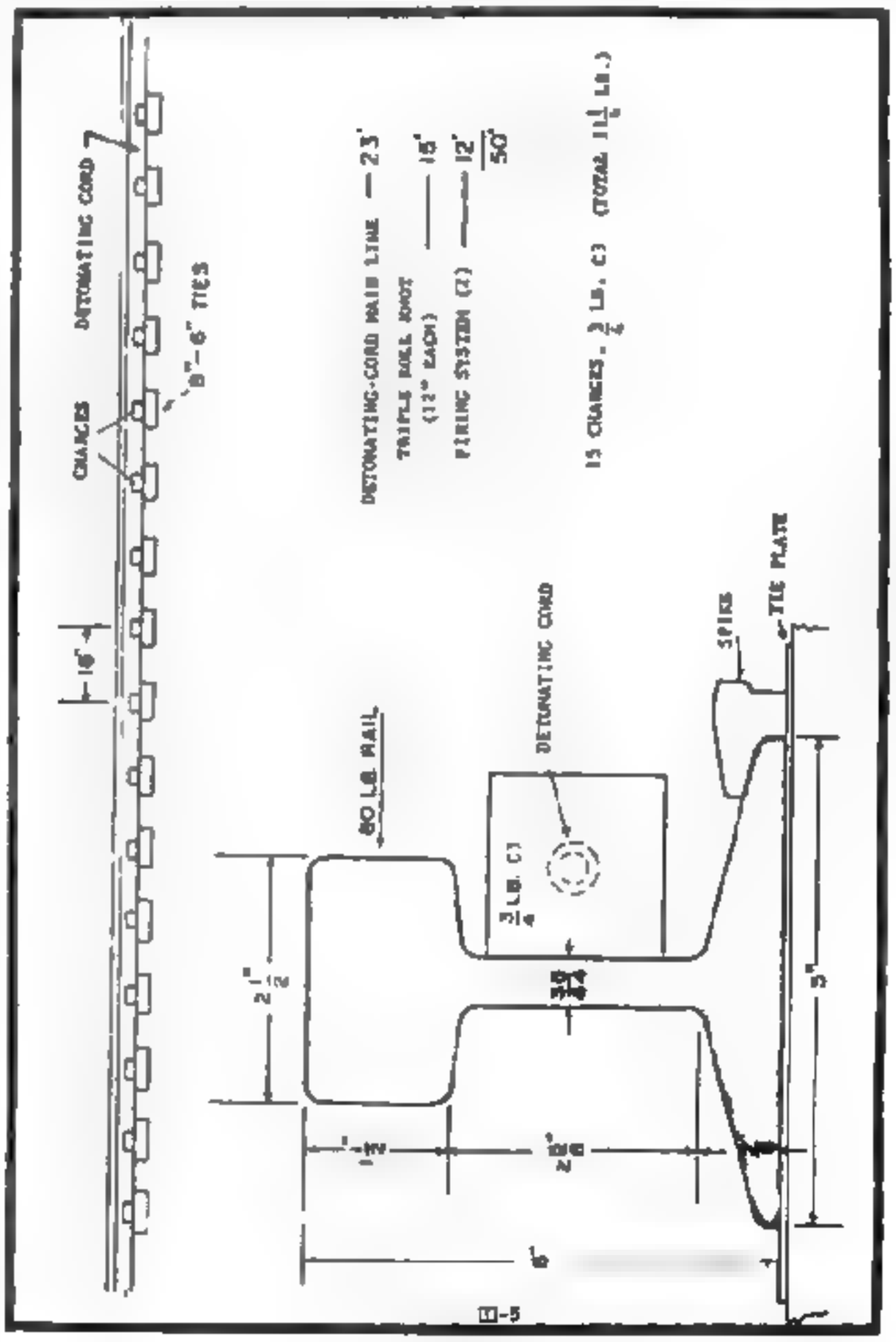
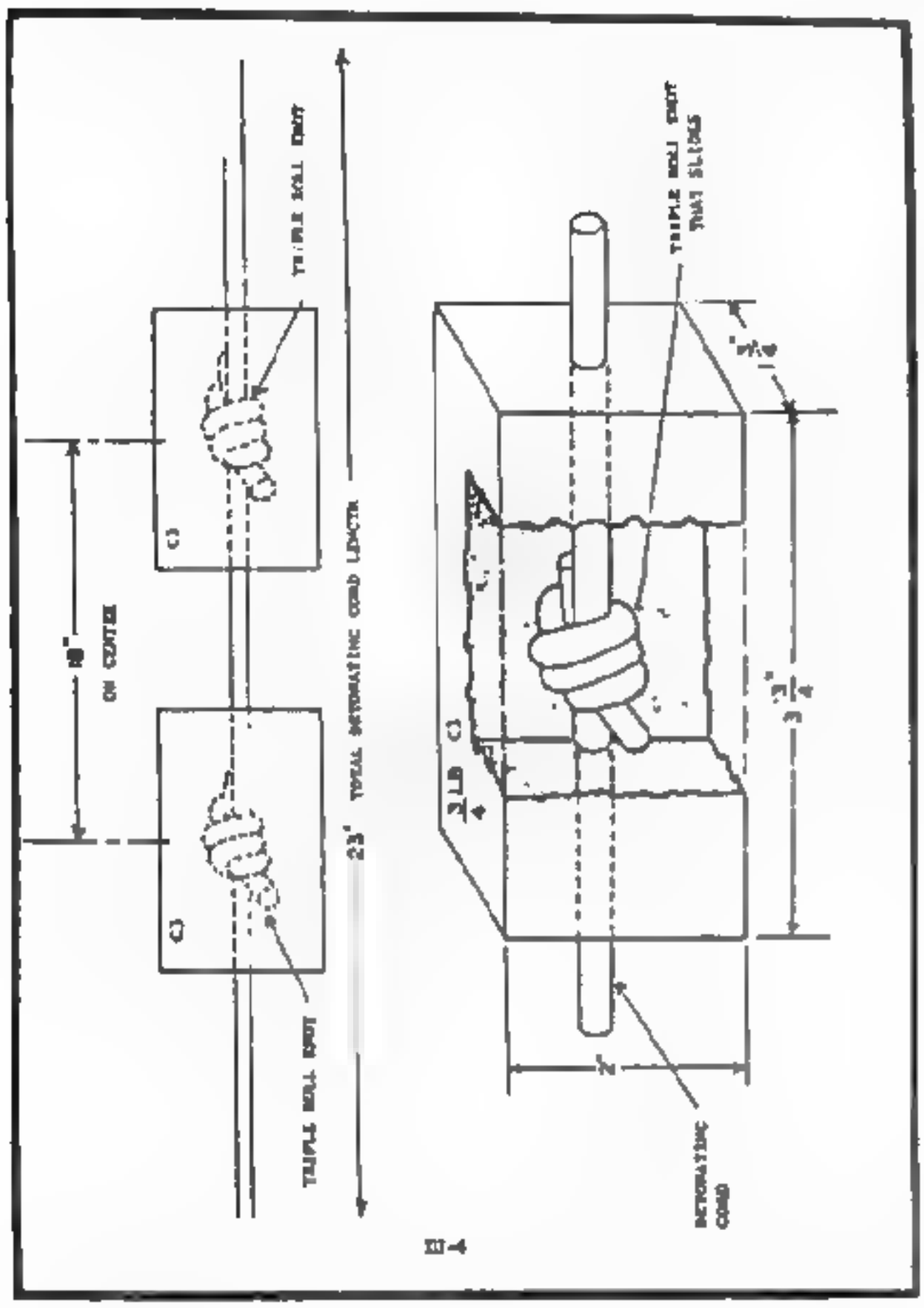


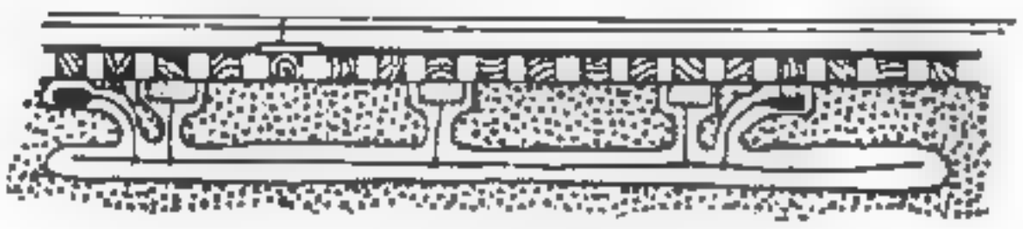
Figure 1. Rocky derailment charge

III-5



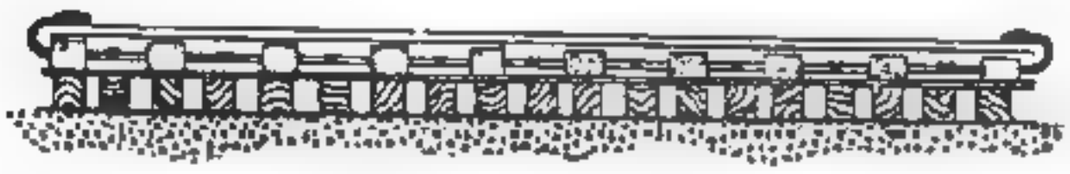
III-4

5-5-1. Derailment System.



Three charges, under every fifth tie. 1 lb each charge.
Delay and time consuming installation; difficult to detect once in place

10-5-1 Derailment System.



Ten charges over every second tie. 1 lb each charge
Silent and quickly installed but easily detected once in place

Figure 3

III-7

c. Firing Systems.

(1) A standard electric firing system is best for continuous and immediate control over initiating the charge. A standard nonelectric system may also be used and timed to insure that the charge explodes just in front of the train; however, both these systems require the presence of an agent at the scene of operation.

(2) All the military booby-trap firing devices can be used to initiate the charge through the movement of the oncoming train. Home made firing devices employing the mechanical principles of the military issue booby-traps can be employed. An electrical blasting cap system may be activated with a flashlight battery used as a simple, field-improvised switch that is closed by the movement of the train. In all cases the firing system is set up to initiate the charge immediately in front of the oncoming locomotive, not under the locomotive. Eighty pound or less rail (5 inches or less in height) takes 1/2 pound to cut. Over 80 pound rail (over 5 inches in height) takes 1 pound to cut.

Junction Destruction

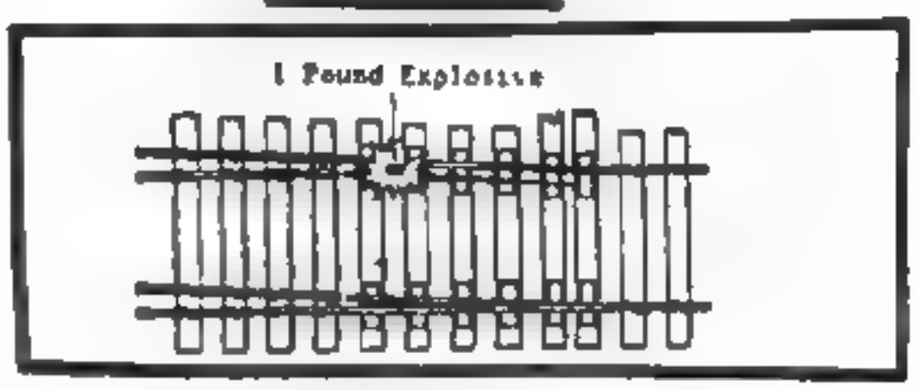


Figure 4

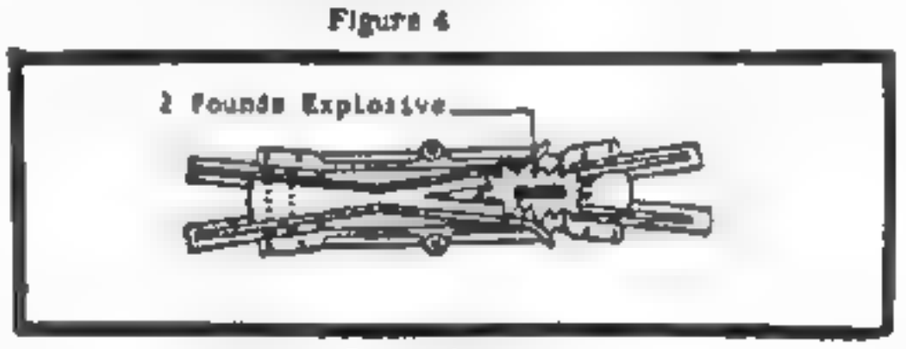


Figure 5

III-8

Figure 6

MANUAL TRACK DISTORTION

Figure 7

(With a jumper wire, provide a path for the electrical current passing through most rails. The wire that is normally between rails will be broken by this manual displacement.)

d. Only plastic explosive should be used, either C3 or C4. Information has been developed for breaching reinforced concrete targets from 1 through 8 feet in thickness. For maximum effect, the charge should be placed a distance equal to the thickness of the target above the base (or above the ground level). Charges placed at the base of a slab will still work but in study they produced craters 25 percent smaller than those placed above the ground

A charge should be constructed to be as close to square as possible to yield optimum results. Charges should be primed either from one corner or from the

III-9

exact rear center. Close contact with the target is required for the best results. Do not deviate from the charge thickness indicated below. Use the M-37 kits as issued when possible to facilitate securing the charge in place. If it is necessary to cut the block, cut them with care so that the density of the explosive is not affected.

TABLE III. CHARGE SIZES

CONCRETE THICKNESS (IN FEET)	(METERS)	CHARGE SIZE (USE C4 BLOCKS)	CHARGE THICKNESS
1	.3	2	1 Block (2")
2	.61	4	1 Block
3	.91	7	1 Block
4	1.22	20	1 Block
		(USE M-37 KITS)	
5		8	2 Blocks (4")
6		9	2 Blocks
7		[illegible]	2 Blocks
8		20	[illegible]

NOTE.

Using the standard breaching technique with an untamped charge above the ground would require 124 lbs of TNT to breach a 4 foot wall. Using the above technique, it would require 30 lbs of C4. For a 7 foot target the standard method uses 317 lbs of TNT. This method uses 140 lbs of C4.

III-10

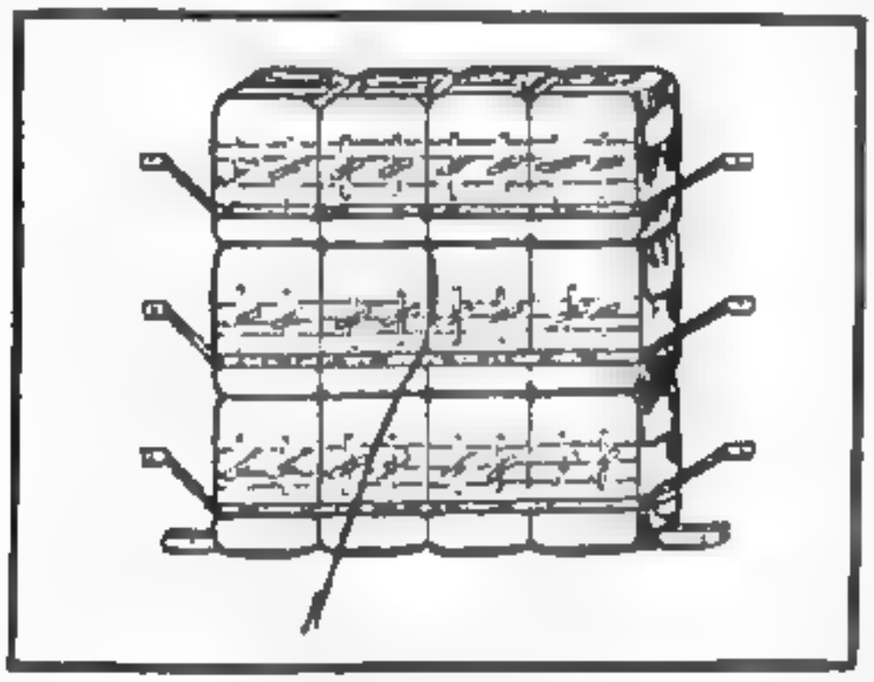


Figure 8 Square Charge

III. CRATERING TECHNIQUE. A delay cratering technique has been developed that produces excellent results, and should be considered if time and materials are available. The charges themselves should be either the standard 40-pound cratering charge, or 30 to 40 pounds of C4 (depending to some extent on the depth and diameter of the bore holes). Depth of the holes should be 4 or 5 feet.

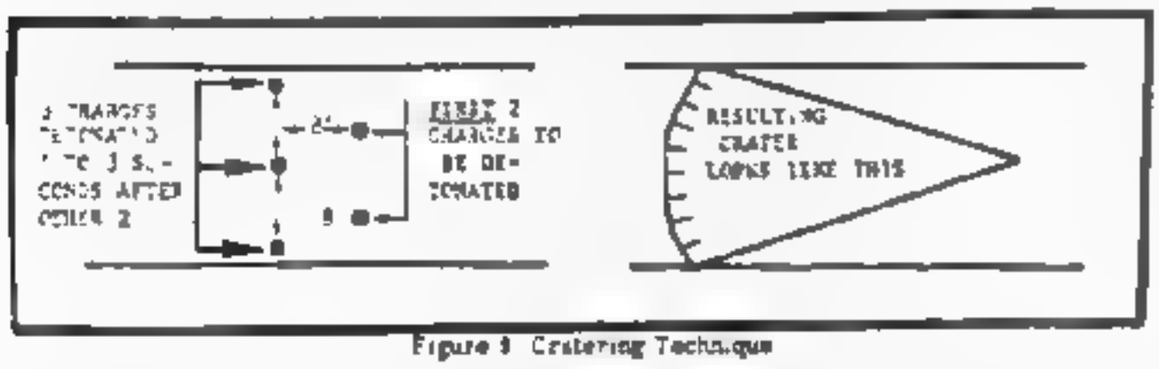


Figure 9 Cratering Technique

III-11

The line of two charges above should be primed to be detonated simultaneously. The line of three charges should all be primed to detonate simultaneously after the correct delay. The line of three charges should be detonated from one to two seconds after the first two charges detonate. The delay can be achieved in a variety of ways, but two separate electrical firing systems are probably the easiest. An expedient method of quickly sinking the bore holes themselves is to set up five 15 pound shaped charges (M2A3) over the desired locations. They should be provided with an improvised 30 inch standoff and all be detonated together. The effect of the delay in the cratering operation is to begin to move a large amount of earth around the first two charges, and then before it can fall back into the hole, the second line of charges displaces it entirely. The resulting teardrop shaped crater is very steep sided on the blunt end (the end having the three delay charges).

IV. Improvised Devices.

a. Bangalore torpedos, if available, can be extremely effective if employed in an antipersonnel role. Best results are obtained if the Bangalore is planted upright in the ground so that the fragmentation effect will radiate out in 360 degrees.

b. The fragmentation hand grenade is a versatile weapon that lends itself to a wide variety of booby trapping actions. One of the simplest booby traps is the grenade-in-a-can. The shipping container or can is affixed to a tree or other permanent object. The grenade, with pull ring removed is placed in the can so that the arming lever is held down by the can. A string or wire is then so placed that the victim will pull the grenade from the can, releasing the lever and detonating the grenade.

c. Improvising electrical booby trap firing devices. Each of the following simple booby traps can be used in conjunction with a wide variety of casualty producing charges, from the 3.5 inch rocket, fired by expedient electrical means, to the bangalore torpedo primed to be detonated in an antipersonnel role.

d. Open loop. The open loop arrangement shown is the ONLY break in an otherwise complete electrical circuit. A wide variety of actions on the part of the victim could result in pulling the two bare ends of the wire together.

II-12

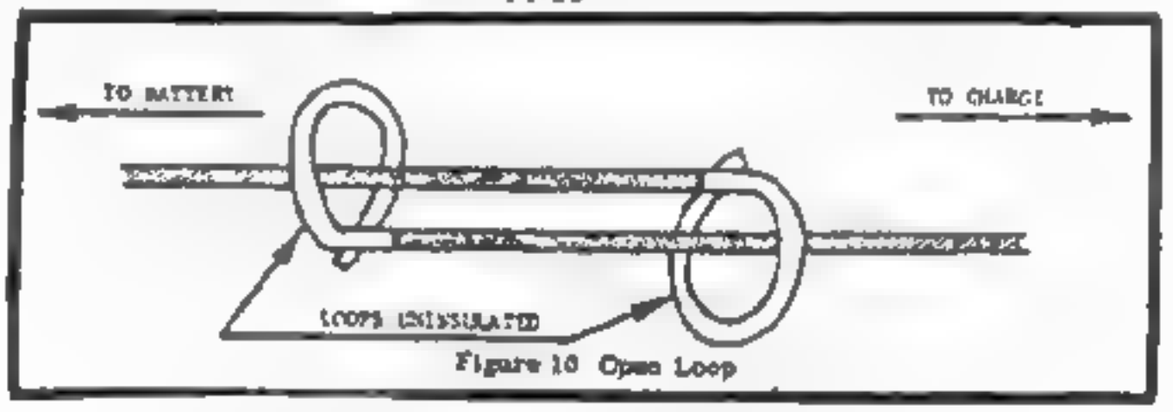


Figure 10 Open Loop

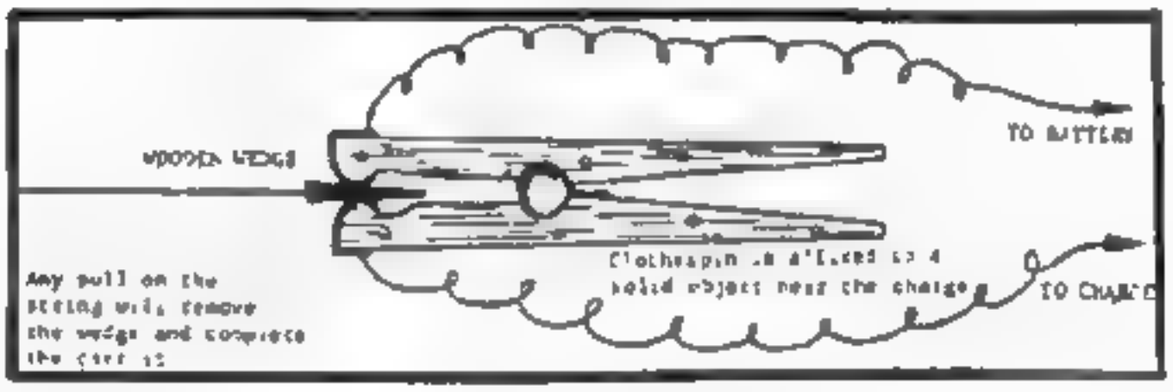


Figure 11 Clothespin

e. Expedient firing of 3.5-inch Rocket. The following technique is one method for firing the rocket electrically. Either the cardboard shipping container or a V-shaped wooden trough may be used as an expedient launcher, with the trough being preferred if available.

III-13

(1) The rocket is prepared for electrical firing by locating the two wire in the nozzle and fin assembly that are coated with clear plastic. (The other green, red, and blue wires are disregarded). After scraping the ends of the clear plastic wires, to provide a good contact for splicing into the firing wire, the connection is made and preferably taped. Experience has indicated that the railing splice is the preferable splice to be used without any adverse effect on rocket accuracy.

(2) The bore-riding safety band is removed and the rocket is placed on the trough so that the bore-riding safety will face a side of the trough during firing. The shorting clip is removed, the rocket is aimed, an electrical power source is provided and the rocket is fired.

(3) Obviously results comparable to those obtained by using the launcher should not be expected. As with all expedient demolition work, trial and error experimentation is stressed. An experienced demolitionist can reliably hit a 55 gallon drum, a relatively small target, up to a range of 40 to 50 yards. In an antitank role, satisfactory results could be expected up to 150 yards. The rocket firing can be controlled by the operator, or can be effected by a wide variety of electrical booby trapping techniques. This expedient use of the rocket of course lends itself equally well to employment in an antipersonnel role.

(4) Power sources can be a 10-cap blasting machine or any of the following dry cell batteries: BA-317/U, BA-270/U, BA-278/U or combinations of the BA-30/U.

(5) Safety precautions should include all of those associated with electrical firing as outlined in FM 5-25, Explosives and Demolitions. Although it would be an extremely rare occurrence, we should operate on the assumption that the rocket may blow up on the launching site and take appropriate precautions to prevent injury from such an accident.

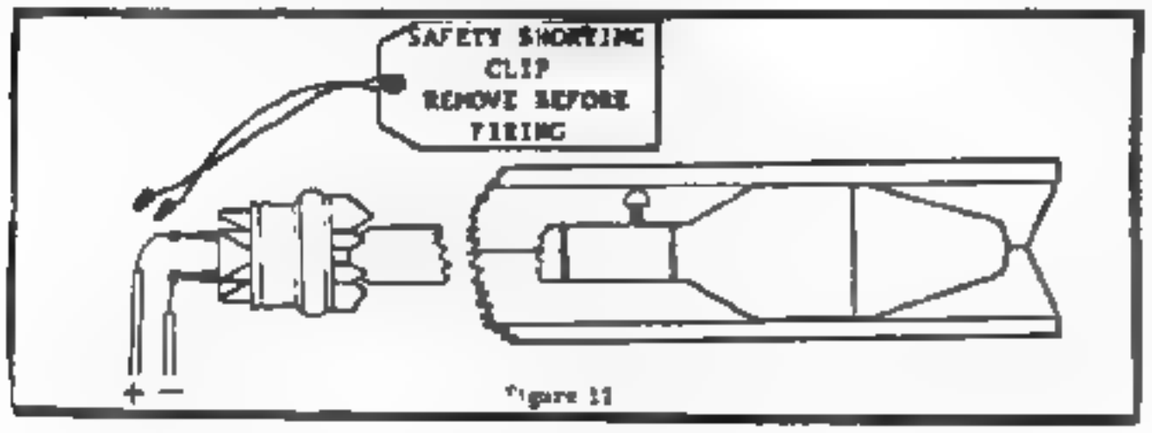


Figure 11

III-14

f. Expedient firing of 3.5 rocket nonelectrically.

(1) Remove all wires from fin assembly

(2) Remove the plastic cone from fin assembly.

(3) Place matchheads or other burning material in contact with the ends of the sticks of propellant

(a) Tape matches around end of fuze.

(b) Place fuze flush against perforated disc, and among matchheads already in the nozzle

(4) Remove the fuze-riding safety band and place the fuze-riding safety pin in depressed position against sides of improvised firing platform.

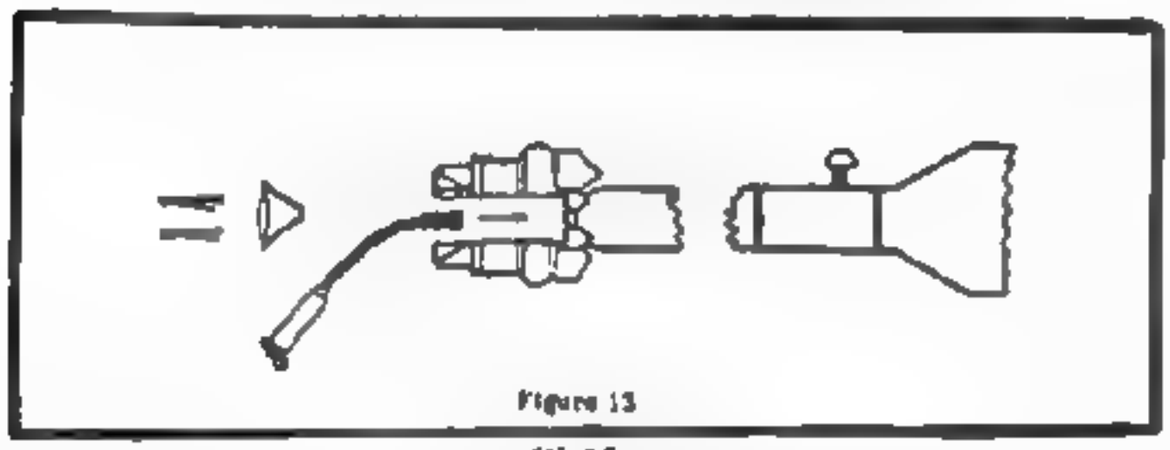


Figure 13

III-15

V. ADVANCED TECHNIQUES. Charges constructed employing advanced techniques generally produce more positive results while using less explosive than required by conventional or standard formulas. Disadvantages of advanced technique charges are that they usually require more time to construct and once constructed they are usually more fragile than conventional charges. Following are rules of thumb for various charges and the targets they are designed to destroy.

a. Saddle Charge. This charge can be used to cut mild steel cylindrical targets up to 8 inches in diameter. Dimensions are as follows: The short base of the charge is equal to one-half the circumference. (Note that previously published dimensions called for three times the base, rather than twice the base.) Thickness of the charge is 1/3 block of C3 or C4 for targets up to 6 inches in diameter: use one-half block thickness for targets from 6 to 8 inches in diameter. Above 8 inches in diameter, or for alloy of steel shafts, use the diamond charge. Prime the charge from the apex of the triangle, and the target is cut at a point directly under the short base by cross-fracture. Neither the saddle nor diamond will produce reliable results against non-solid targets, such as gun barrels. These charges benefit from prepackaging or wrapping, providing that no more than one thickness of the wrapping material is between the charge and the target to be cut. Heavy wrapping paper or aluminum foil are excellent, and parachute cloth may be used if nothing else is available. (See figure 14.)

b. Diamond Charge. This charge can be used to cut hard or alloy steel cylindrical targets of any size that would conceivably be encountered. It has reliably been used, for instance, against a destroyer propeller shaft of 17 inch diameter. Dimensions are as follows: The long axis of the diamond charge should equal the circumference of the target, and the points should just touch on the far side. The short axis is equal to one-half the circumference. Thickness of the charge is 1/3 thickness of a block of C3 or C4. To prime the charge, both points of the short axis must be primed for simultaneous detonation. This can be accomplished electrically or by use of equal lengths of detonating cord, with a cap crimped on the end that is inserted into the charge. As detonation is initiated in each point of the diamond and moves toward the center, the detonating waves meet at the exact center of the charge, are deflected downward, and cut the shaft cleanly at that point. The diamond charge is more time consuming to construct, and requires both more care and more materials to prime. Transferring the charge dimensions to a template or cardboard or even cloth permits relatively easy charge construction (working directly on the target is extremely difficult). The completed wrapped charge is then transferred to the target and taped or tied in place, insuring that maximum close contact is achieved. The template technique should be used for both the saddle and diamond charges.

III-16

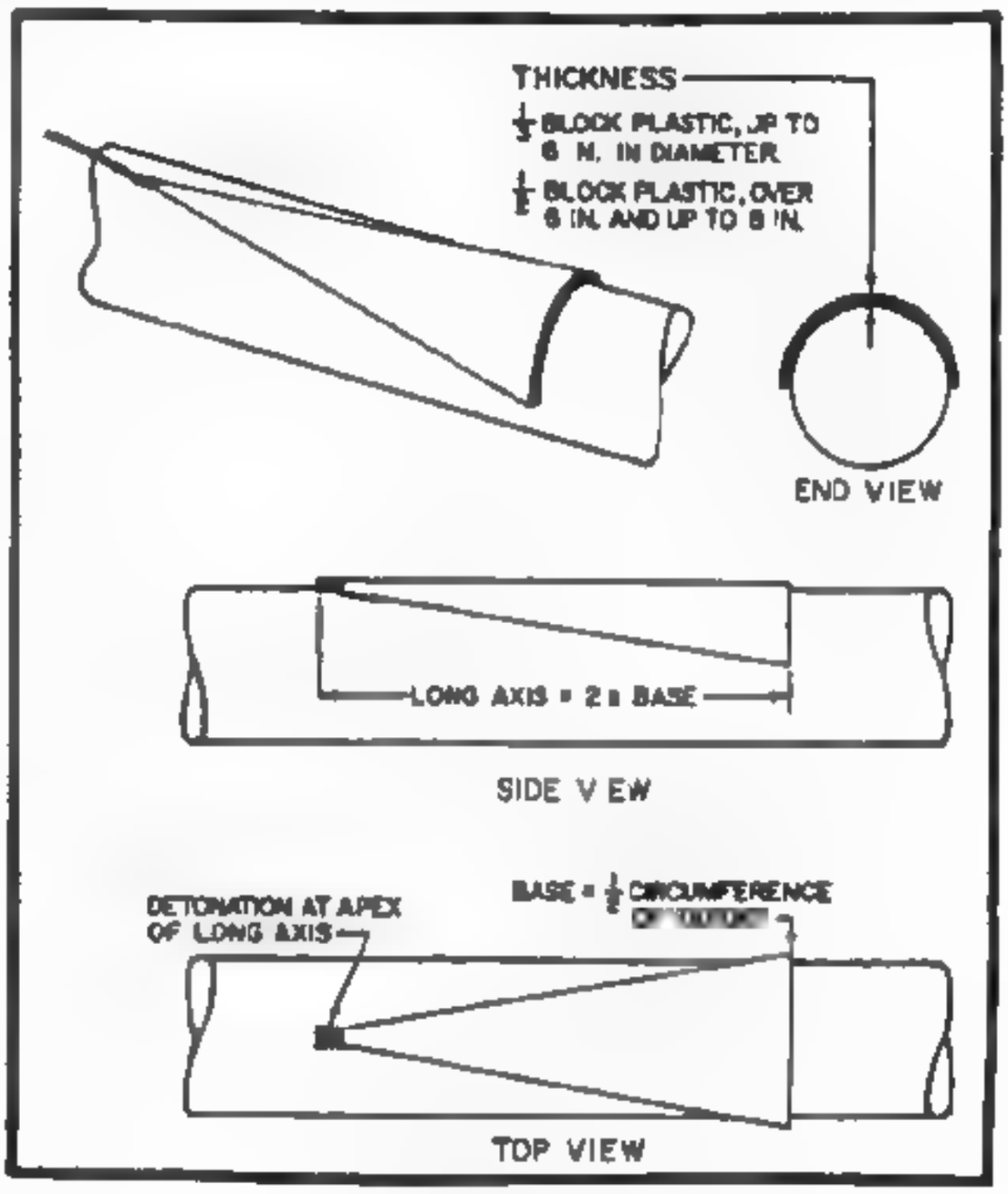
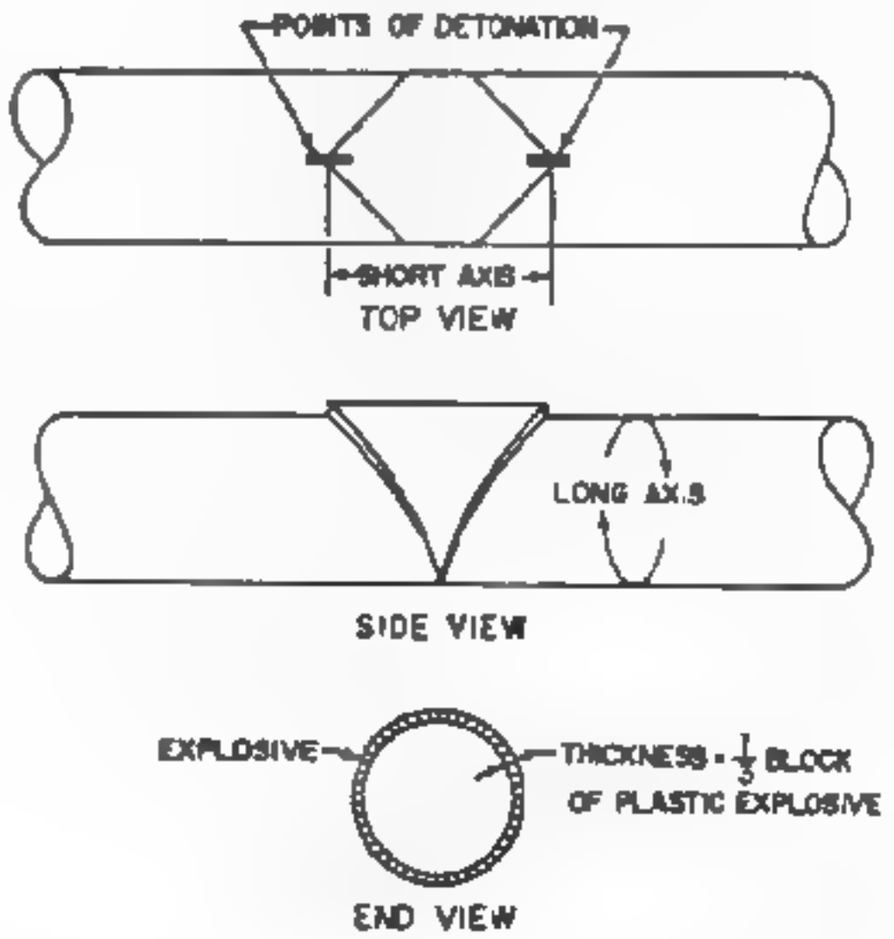


Figure 14 Saddle charge

III-17



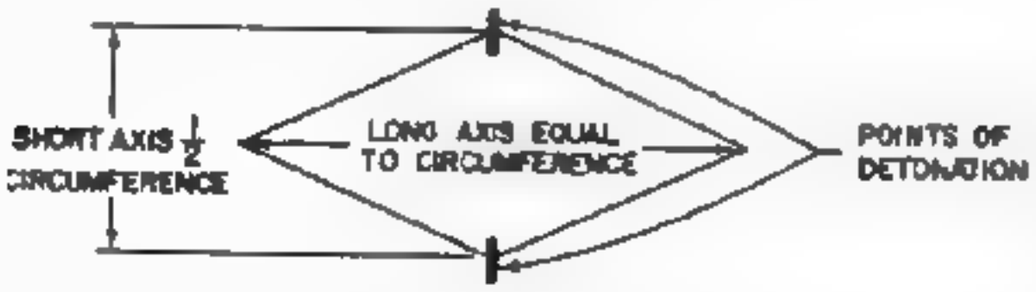


Figure 15 Diamond Charge

III-18

c. **Ribbon Charge.** To cut flat or non-cylindrical steel targets the ribbon charges produce excellent results at a considerable savings in explosive. Dimensions are as follows: the thickness of the charge is equal to the thickness of the target to be cut. (Note: never construct a charge less than 1/2 inch thick.) Width of the ribbon is equal to twice the thickness of the target. Length of the charge is equal to the length of the desired cut. Prime from an end; and for relatively thin charges, build up the end to be primed. Build up corners if the charge is designed to cut a target such as an I-beam. Tamping is unnecessary with the ribbon charge. A frame can be constructed out of stiff cardboard or plywood to give rigidity to the charge and to facilitate handling, carrying, and emplacing it. The ribbon charge is effective only against targets up to 2 inches thick, which effectively accounts for the great majority of flat steel targets likely to be encountered.

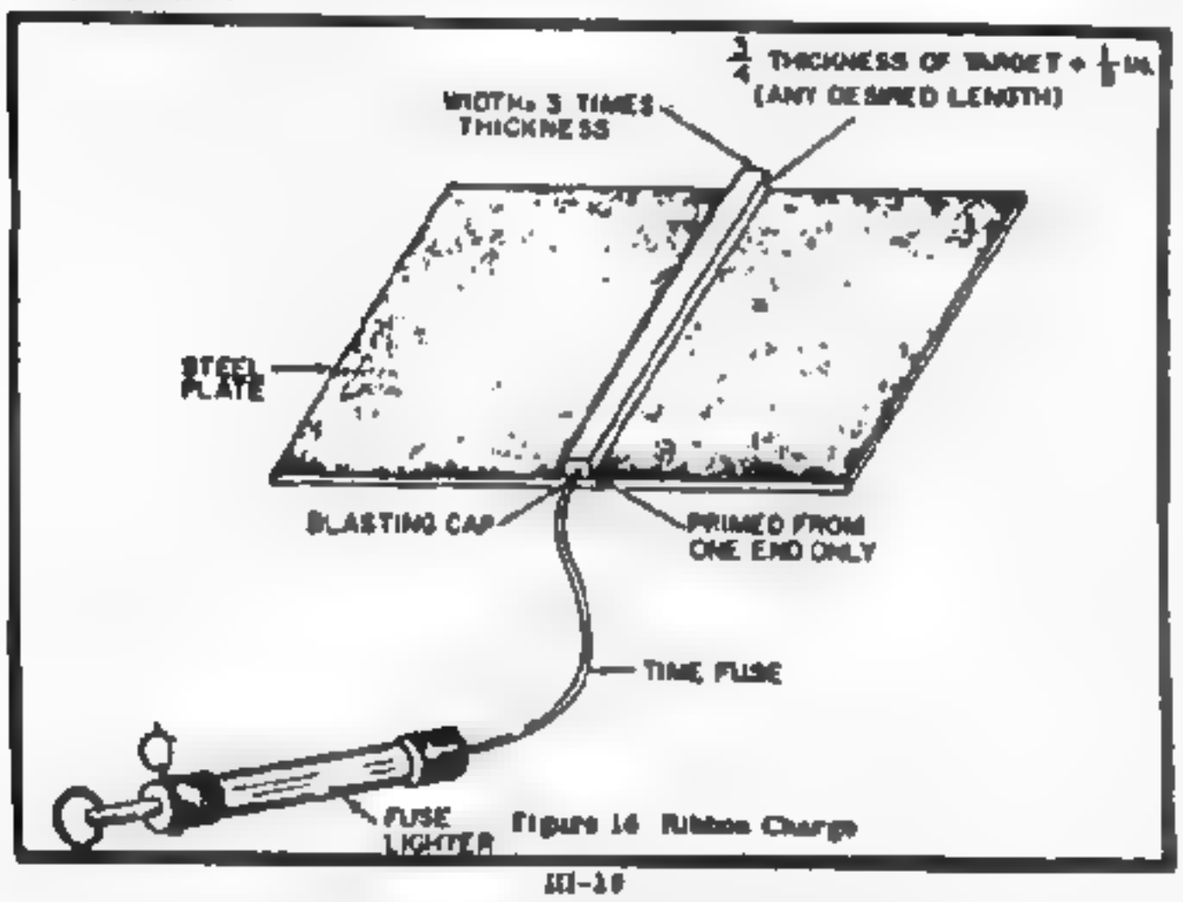


Figure 16 Ribbon Charge

III-19

d. **Paste Explosive.** Excellent results have been obtained in cutting railroad rails and other steel targets by using improvised paste explosive. An example of paste effectiveness follows: the standard steel cutting formula, P = 1/3 A, yields an answer of 560 grams of explosive required to cut a rail 90 lb/yard. Eighty grams of paste explosive were actually used, and this charge removed more than a foot of the track.

e. **Shaped Charges.** If available, manufactured shaped charges will always give results far superior to those produced by any improvised shaped charges. The angle of the cavity of an improvised shaped charge should be between 30 and 60 degrees. Stand-off should be from 1 to 2 times the diameter of the cone. Height of the explosive, measured from the base of the cone should be twice the height of the cone. Exact center priming and tightly packed C4 is important. Trial and error experimentation in determining optimum stand-off is necessary. A point worth mentioning in preparing hollow-bottomed bottles for shaped charge use is to hold the bottle upright when burning the string soaked with gasoline. As the flame goes out submerge the bottle, neck first, in water; and if properly done, the bottle will break cleanly where the string was burned. Hemispherical cavities will produce more surface damage on the target but less penetration. A true cone with an angle of approximately 45 degrees will produce more penetration, which ultimately is the desired results. (See figure 17.)

f. **Platter Charge.** The platter charge has been developed to breach volatile fuel containers and ignite their contents, from distances up to 30 yards depending on the size of the target. The platter can also employed to destroy small electrical transformers or other similarly "soft" targets, again from a distance.

Platters do not have to be round or concave although a round, concave platter is undoubtedly best. (The concave side of the platter faces the target, and the explosive goes on the reverse, or convex, side.) First, square or rectangular platters are permissible with steel being the best material. Platter size preferably should be between 2 to 6 pounds, and weight of explosive should approximately equal platter weight. The explosive should be uniformly packed behind the platter and it must be primed from exact rear center. (Build up the C4 in the center of the charge if necessary to insure detonation.) A container is completely unnecessary for the platter charge as long as some way is found to hold the plastic firmly to the platter; tape is acceptable. The range is something in the neighborhood of 25 to 50 yards. With practice, a good demolitionist can hit a 55 gallon drum, a relatively small target, at 25 yards 90 percent of the time. The largest glass or ceramic platters do not give results approaching those of steel.

III-20

g. **Improvised Claymore or Improvised Grapeshot Charge.** One of the most effective antipersonnel charge that can be improvised in the field requires the use of C4 and only a few other widely available materials. A container such as a number 10 can is excellent, although virtually any sized can or container could obviously be used. The ratio of projectiles ideally should be small pieces of steel although other objects can be used. Iron, brass, and stones can be used but, for the more fragile items, reduce the weight of explosive and add a few inches of buffer material, either earth or leaves, between the explosive and the projectiles. To prepare the charge, place the projectiles in the container. Next place a layer of thick cloth, felt, cardboard, wood, or some similar material over the projectiles. Whenever in doubt about the amount of explosive to use, use a lighter rather than a heavier charge. Again trial and error experimentation is extremely important in arriving at the best charge loading. The effectiveness of the finished product in this case makes all such efforts extremely worthwhile. Pack the C4 uniformly behind the separator disc, prime from exact rear center, and aim the charge toward the center of the desired target area. We obtain excellent results, in dispersion, penetration, and range, by using expended .45 caliber slugs. The main problem to guard against is the tendency to overcharge. A relatively small amount of C4 is all that is necessary to propel the projectiles; anything more will pulverize them.

h. **Soap Dish.** An excellent charge for both rupturing and igniting the contents of volatile fuel containers is the soap dish which, in contrast to the platter charge, must be placed directly on the target. Using a standard GI soap dish, containers up to 100 gallons can be reliably attacked. Charge proportions are as follows: Equal parts by volume of plastic explosive and thermate mix are placed in the container to be used, always insuring that the incendiary mix is placed against the target. The mix can be composed of a number of compounds, among which are: three parts potassium chlorate and two parts sugar, or two parts aluminum powder to three parts of ferric oxide. In lieu of these improvised incendiary mixes, the contents from thermate grenades can be used or military dynamite may be used as the explosive and match heads as the incendiary. As a rule of thumb, a thin cigar box (from an inch and a half to an inch and three-quarters thick) loaded as specified above with one-half C4 to one-half incendiary mix will reliably rupture and ignite volatile fuel containers of up to 1,000 gallon capacity. A charge of approximately twice the size will successfully attack containers of up to 5,000 gallon capacity. To prime the charges always insure that the cap is inserted into the explosive and not the incendiary mix. Holding the charge in place may be accomplished by the use of magnets or adhesive. Always insure that the charge is placed below the fuel level in the container.

III-21

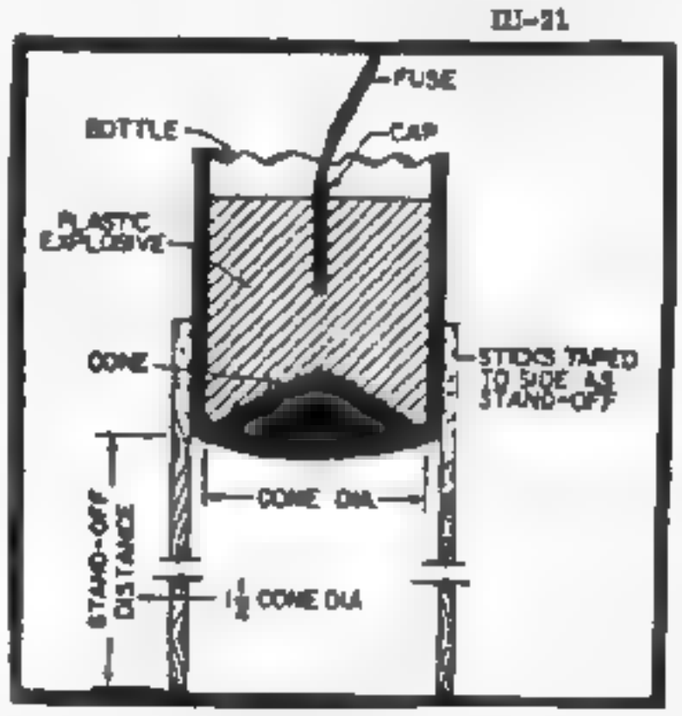


Figure 17 Shaped Charge

1-STANDOFF-1 to 2 times diameter of cone

2-CONE ANGLE-30° to 60°

3-EXPLOSIVE DEPTH-2 times height of cone

4-DETONATED REAR DEAD CENTER

i. **Opposed Charge.** (Also called the "counterforce" or "ear muff" charge.) Within its limitations, which are quite restrictive, the opposed charge offers dramatic savings in explosives for destroying reinforced concrete targets. The rule of thumb for construction is as follows: for each foot of target thickness, up to a maximum of 4 feet, use 1 pound of C4; for fractions of a foot, go to the next higher pound. Divide the total amount of C4 exactly in half, placing one half of the charge on each side of the target, diametrically opposite each other. (This brings up one limitation, the requirement to have two sides of the target accessible.) Prime the two charges to detonate exactly simultaneously, and the target will be destroyed as the shock waves meet in the center of the target and, in effect, cause it to virtually explode from within. It will be noted that the charge size has been reduced by one-half the amount called for in previous publications. This charge is very effective and reliable against targets that are approximately

square and not much much larger than 4 feet square. (See figure 18).

j. Improvised Cratering Charge. Ammonium nitrate fertilizer is a material that is readily available in many parts of the world. With AN and one other simple ingredient we have the ability to "tailor make" cratering charges to practically any size or configuration. A rule of thumb for the construction of an improvised cratering charge is as follows: to each 25 pounds of ammonium nitrate fertilizer, which should be the prilled or pelleted variety, add approximately

III-22

1 quart of diesel fuel, motor oil, or gasoline. The motor oil may be drained from a crankcase, which will not impair the effectiveness of the charge. Allow the charge to soak for 1 hour, prime with 1 pound of TNT, or its equivalent, tamp well in an appropriate bore hole, and detonate. The results obtainable with this charge compare very favorably with the manufactured variety. The prilled Ammonium Nitrate fertilizer should be of a kind having at least 33 1/3 percent nitrogen content and care should be exercised to see that the fertilizer used is not damp. Obviously it cannot be left for extended times in a borehole or water will reduce the effectiveness of the charge. When difficulty is encountered in producing a borehole diameter that is capable of accommodating the bulk of the manufactured 40 pound cratering charge, 8 1/4 by 17 inches, excellent results can be obtained by pouring and tamping the improvised AN cratering charge into the available space.

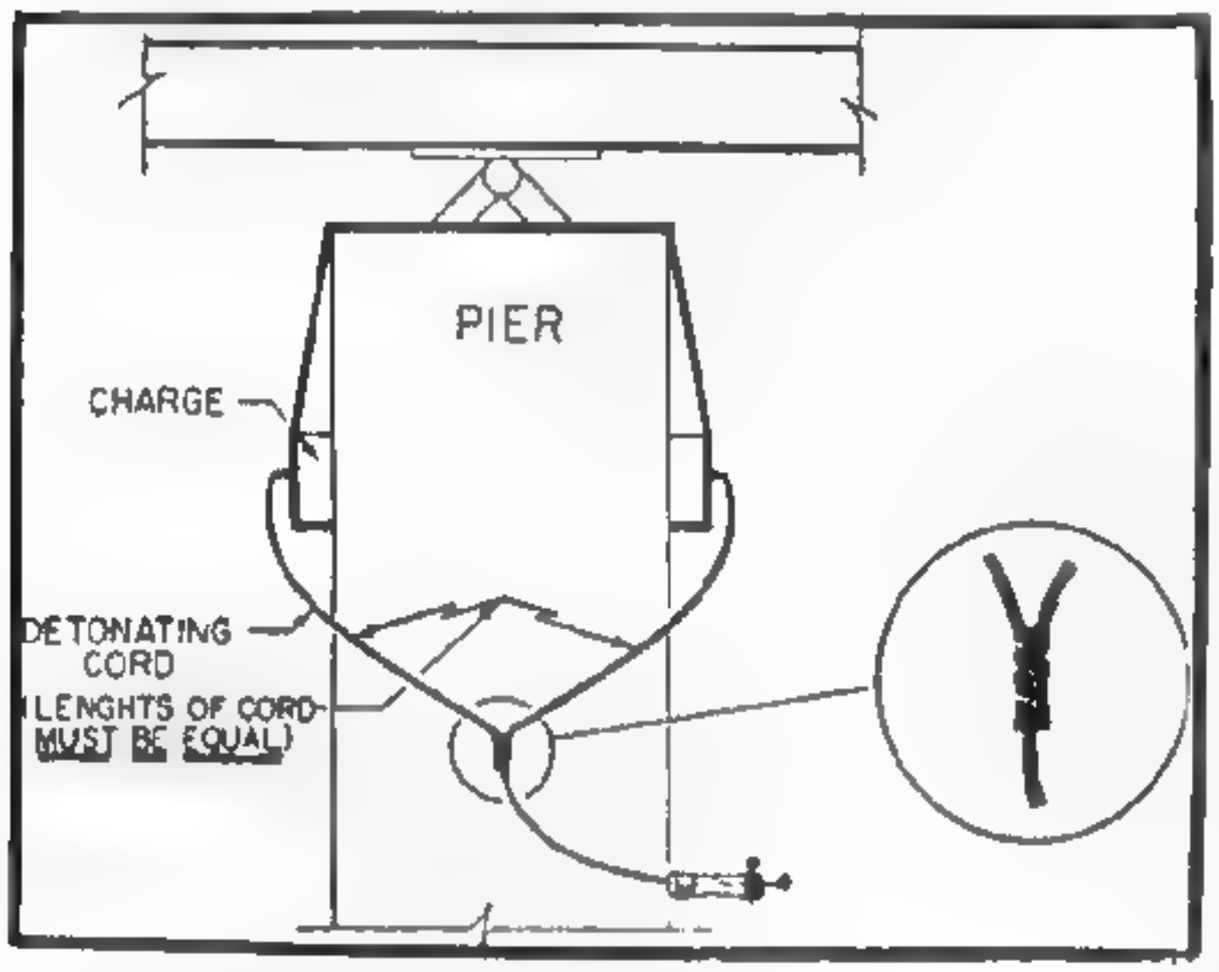


Figure 18

III-23

k. Improvised Ammonium Nitrate Satchel Charge. While the cratering charge referred to earlier is undeniably a good one, it is really only suitable for cratering use. A more manageable charge can be produced from AN, using wax as the second ingredient, rather than oil. The procedure for making this charge is merely to melt ordinary paraffin and stir in AN pellets, insuring that the wax is thoroughly mixed with the AN while still hot. Before the mixture hardens add a one-half pound block of TNT, or its equivalent, as a primer. A number 10 can makes a good container for this charge although practically anything may be used. The addition of suitable shrapnel material and a handle to the exterior of the charge makes an excellent expedient satchel charge that is more manageable than the AN and oil mixture and much less susceptible to moisture. In fact, this charge can be stored for extended periods without regard to humidity and without loss of effectiveness.

l. Dust Initiator. The employment of a small initiator charge to make use of explosive energy provided at a target site is an economical means of destroying certain types of targets. An improvised dust initiator charge can be constructed as follows: To make the standard 1 pound charge use half explosive and half incendiary mix. The explosive may be either powdered TNT (obtained by crushing the TNT in a canvas bag) or C3. C4 does not properly mix with the incendiary and will not produce the desired result. The incendiary mix may be two parts of aluminum powder to three parts of ferric oxide; magnesium powder may be used in lieu of aluminum powder. If used with powdered TNT, the two should be thoroughly mixed. If used with C3, the incendiary mix should be thoroughly mixed throughout the half-pound of explosive. The dust initiator requires a "surround" which is merely the addition of a suitable, finely divided (dust) material or a volatile fuel such as gasoline. The DI works best in an inclosed space; and such targets as boxcars, warehouses, and other relatively windowless structures are best suited to an attack by this means. A rule of thumb for its employment is that three to five pounds of cover or surround should be provided for each 1,000 cubic feet of target. The 1 pound DI charge will effectively disperse and detonate up to 40 pounds of cover charge. The effect of the surround as it is first scattered and then detonated by the long-lasting flame of the DI's explosion is to increase the internal explosive pressure from 500 to 900 percent over the effect of the DI being detonated without a surround. If used with gasoline the optimum results are obtained by only using 3 gallons of the fuel. The addition of more gasoline not only does not produce better results, the fuel usually will not even be detonated. A large number of dust materials can be used as a surround, including coal dust, cocoa, bulk powdered coffee, confectioners sugar, tapioca, and powdered soap. A good expedient DI charge can also be produced by packaging the contents of two thermate grenades around a stick of military dynamite. (Note that this is just the DI charge to which a surround must be added.)

III-24

VI. IMPROVISED INCENDIARIES, EXPLOSIVES AND DELAY DEVICES.

> Caution: As a general rule improvised explosives and incendiaries are much more dangerous to handle than conventional explosives. Such mixtures as the chlorate-sugar mix mentioned below can be ignited or detonated by a single spark, excessive heat, or merely by the friction generated by stirring or mixing the ingredients together. The danger in handling these items cannot be over emphasized.

a. Chlorate-Sugar Mix. This mixture can be either an incendiary or an explosive. Sugar is the common granulated household variety. Either potassium chlorate or sodium chlorate may be used; potassium is preferred. Proportions can be equal parts by volume, or 3 parts of chlorate to 2 parts of sugar preferred. Mix it on a non-sparking surface. Unconfined, the mix is an incendiary. Confined in a tightly capped length of pipe it will explode when a spark is introduced. Such a pipe bomb will produce casualties, but will not be suitable for breaching or cutting tasks. Concentrated sulfuric acid will ignite this fast burning incendiary mixture. Placing the acid in a gelatin capsule, balloon, or other suitable container will provide a delay, (length of which depends on how long it takes the acid to eat through the container).

b. Potassium Permanganate And Sugar. Another fast burning, first fire mix is obtained by mixing potassium permanganate, 9 parts, to one part sugar. It is somewhat better than the chlorate sugar mix, and can be ignited by the addition of a few drops of glycerine.

c. Sawdust and Wax. An effective and long burning incendiary can be produced by adding molten wax or tar to sawdust. The advantage of this incendiary is that its components are truly universally available.

d. Matchheads. A quantity of matchheads cut from common safety matches will make either a fast burning incendiary or, if confined, an explosive. A length of pipe filled with matchheads and capped and fused makes an effective antipersonnel bomb. Again extreme caution must be exercised in handling of matchheads in

III-25

bulk--a single spark will detonate or ignite them.

e. Improvised Napalm. To either gasoline or kerosene add finely cut soap chips. Pure SOAP must be used, not detergents. Working in the open, use a double boiler with the bottom portion filled approx 3/4 full of water. Heat until fuel comes to a boil and then simmers. Stir constantly until the desired consistency is reached: Remember that it will thicken further on cooling. Trial and error experimentation will determine proper amounts for best results.

f. Improvised Thermite Grenade. The main burning agent, the thermite, is composed of 3 parts of iron oxide to 2 parts of aluminum powder. A ceramic flower pot makes a good container for the thermite. A potassium chlorate and sugar first fire mix of 3 parts chlorate and 2 parts sugar is placed in a paper tube running down through the thermite. When the chlorate is ignited, it in turn ignites the thermite, which can be used to attack mild steel. This thermite mix burns at approx. 4,000 degrees.

g. Molded Brick Incendiaries. Proportions are 3 parts aluminum powder, 4 parts water and 5 parts plaster of paris. Mix the aluminum and plaster thor-

oughly together, then add the water and stir vigorously. Pour the resulting mix into a mold, let harden, and dry for 2 to 5 weeks. While they are difficult to ignite, a dry mix of 3 parts of oxide and 2 parts of aluminum powder should be used. These bricks burn with intense heat and are suitable for melting mild steel.

h. C4 As An Incendiary. Most plastic explosives, including C3 and C4 can be used as an incendiary. They are easy to ignite and burn with a hot flame of long duration.

i. Sulfuric Acid can be used to ignite chlorate and sugar. An expedient method of obtaining sulfuric acid is as follows: Drain the liquid from one or more wet cell batteries, place it in a glass, pottery or ceramic container, and heat it. As the liquid comes to a boil it will begin to emit a dense white smoke. Remove the remaining liquid from the heat, allow to cool, and place it in a tightly stoppered glass bottle. Test the acid before each operational use.

j. Fire bottle. Fill a glass bottle about one-fifth to one-fourth full with sulfuric acid. Fill the remainder with gasoline, kerosene, or a combination of both. Add water to potassium chlorate and sugar mix, and soak rags in the mix. Wrap the rags around the bottle, tie in place, and allow to dry. When thrown, the bottle will break, the acid will ignite the chlorate sugar saturated rags, which in turn will ignite the fuel.

k. Thermite.

Use any size can with sticks tied or taped to sides and cut small hole in bottom. Cover bottom with paper. Place round stick wrapped in paper in middle of can. Fill bottom of can 1/4 inch with magnesium. Over this place mixture of 3 parts ferric oxide and 2 parts aluminum powder. Remove stock and fill hole with mixture 3 parts potassium chlorate and 1 part sugar. On top of this place paper bag containing chlorate-sugar mixture. Place fuze in top. Tamp with dirt or clay.

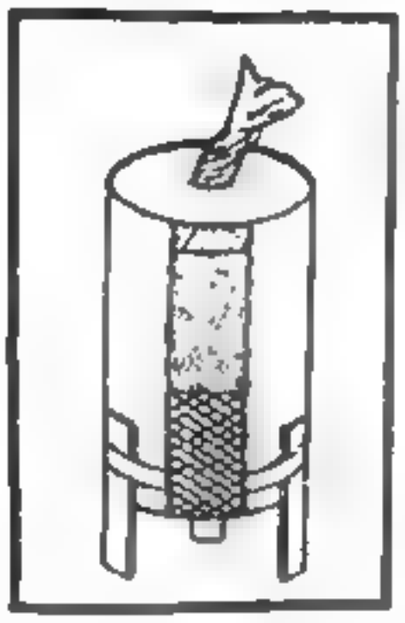


Figure 19

Fill bottle with napalm, jelly gas or 2 to 1 ratio mixture of gas and oil. Use wick of rag or cotton dipped in wax. Light before throwing.

l. Molotov Cocktail.

Figure 20

e. Satchel Charge.

Fill # 10 can with mixture of ammonium nitrate and melted wax, stirring vigorously to insure a complete mix. Prime with small amount of C4 or TNT before mixture hardens. Add a rope handle for convenient improvised satchel charge.

III-27

d. Improvised Black Powder.

(1) Materials required	Percent by Wt.	Parts by Vol.
Potassium Nitrate	74	25
Powdered Charcoal	16	3
Sulpher	10	2

(2) Procedure.

(a) Dissolve potassium nitrate in water using a ratio of three parts weight of water to one part nitrate.

(b) In a second container, dry mix the powdered charcoal and sulpher by stirring with a wooden stick or rotating in a tightly closed container.

(c) Add a few drops of potassium nitrate solution to the dry mixture and blend to obtain a thoroughly wet paste. Then add the rest of the solution and stir.

(d) Pour the mixture into a shallow dish or pan and allow to stand until it evaporates to a paste-like consistency. Mix the paste thoroughly with a wooden stick to assure uniformity and set aside for further drying.

(e) When the mixture is nearly dried, granulate by forcing through a piece of wire screening. The granules are then spread thinly and allowed to dry.

e. Improvised Fuse.

(1) String Fuse-(Hot) 3/4 cup water, 1 teaspoon potassium chlorate-boil

[redacted]

(2) String Fuse-soak in gasoline and dry. Burns slowly.

(3) String Fuse-(Cold) 3/4 cup water, 2 teaspoons potassium nitrate.

III-28

f. Improvised Grenades.

(1) 7.5 parts potassium nitrate or sodium nitrate, 1.5 parts charcoal, 1 part sulphur (no detonator, just heat)

(2) 3 parts sodium chlorate, 2 parts sugar. Contain in a lead pipe (no detonator, just heat)

g. Types of Delays:

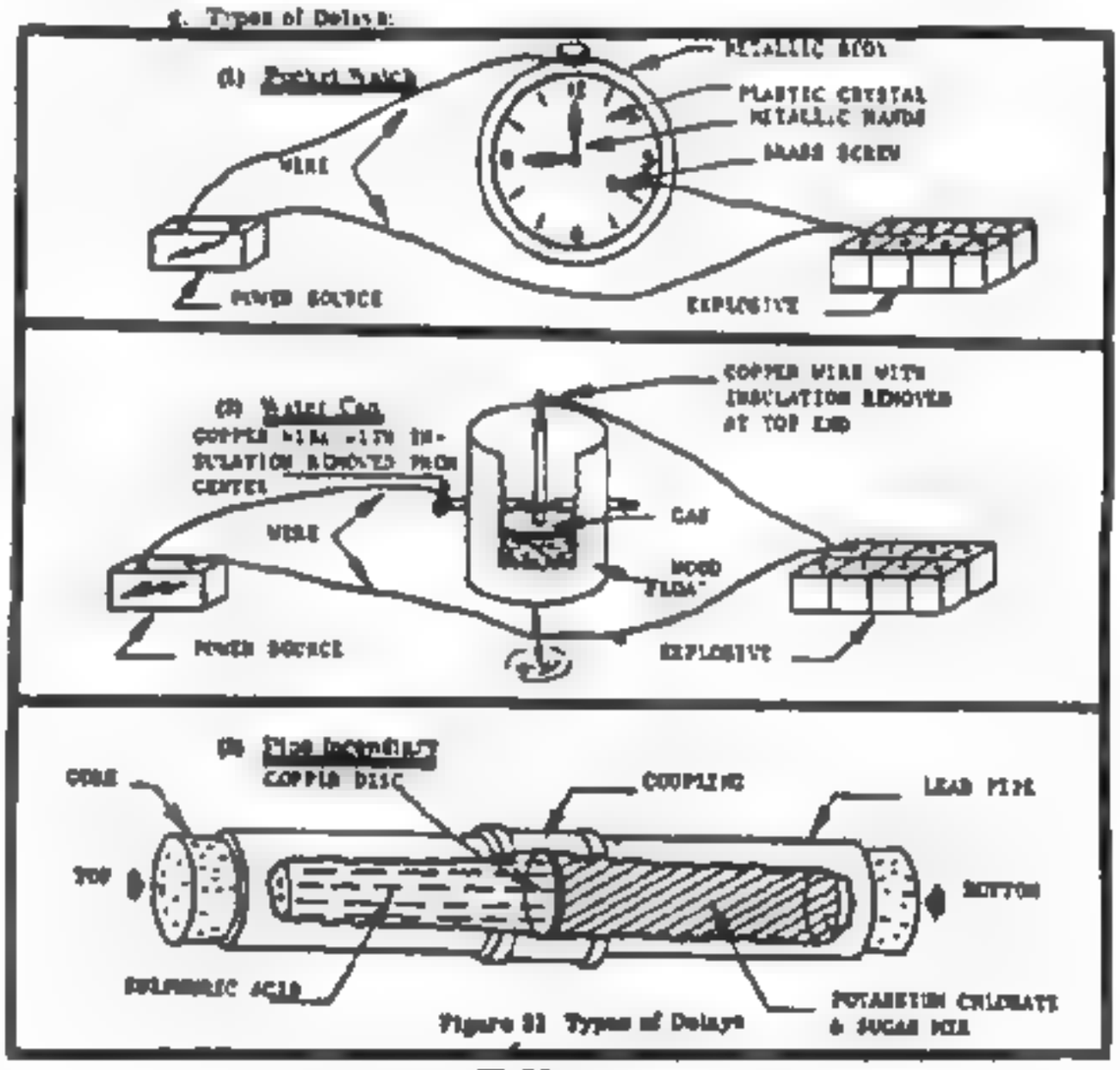


Figure 21 Types of Delays

III-29

h. Flame Illuminator.

(1) Fill container 2 inches from top w/thickened fuel and seal tightly.

(2) Put three wraps det cord on top outside of rim pack with dirt or mud.

(3) Wrap grenade with det cord and place next to container. Tie to main det cord line.

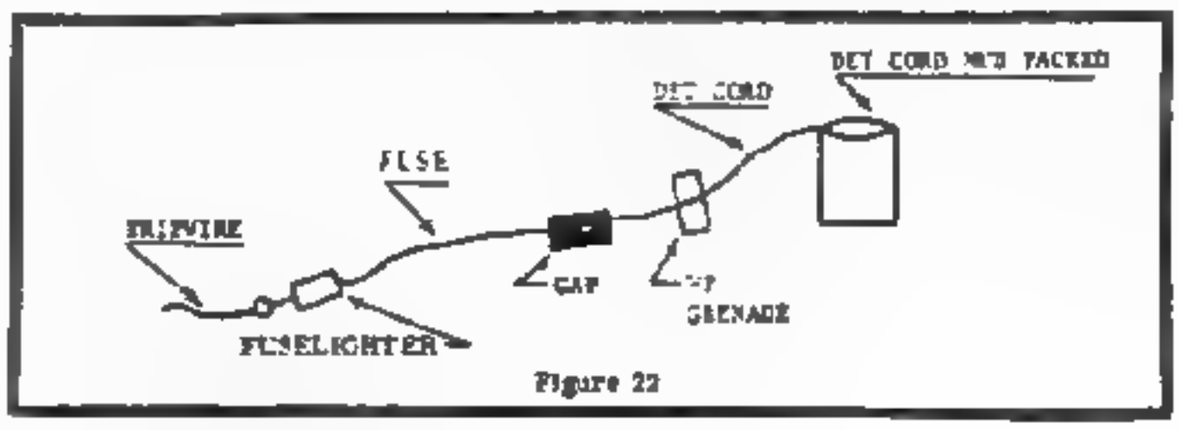


Figure 22

1. Bunch Flare (Burns for 90 minutes, 1 grts dia 50 Meters).

(1) Remove cross bars from metal 60mm mortar can.

(2) Punch 3 3/8" holes in each side 1/2 way between top and bottom.

(3) Punch hole not bigger than 1/8" in bottom of 81mm mortar metal shell container.

(4) Temporarily fill holes, fill container 3/4 full w/thickened fuel, apply heavy grease to caps and affix tightly.

(5) Place 81 containers caps down in 60 mortar container, wedge tight with stones, etc, then fill 60 mm mortar can with thickened fuel up to holes.

(6) Remove plugs from 1/8" holes in bottom of 81mm shell container.

(7) Tie illumination hand grenade between 81 mm cans just above level of 60 mm can. Run trip wire from grenade pin

DRIED SEED TIMER

A time delay device for electrical firing circuits can be made using the principle of expansion of dried seeds

MATERIAL REQUIRED:

Dried peas, beans or other dehydrated seeds
Wide mouth glass jar with nonmetal cap
Two screws or bolts
Thin metal plate
Hand drill
Screwdriver

PROCEDURE:

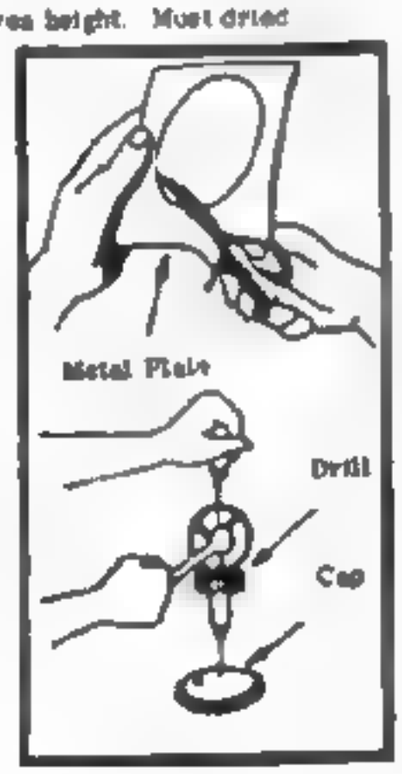
1. Determine the rate of rise of the dried seeds selected. This is necessary to determine delay time of the timer.

a. Place a sample of the dried seeds in the jar and cover with water.

b. Measure the time it takes for the seeds to rise a given height. Most dried seeds increase 50% in 1 to 2 hours

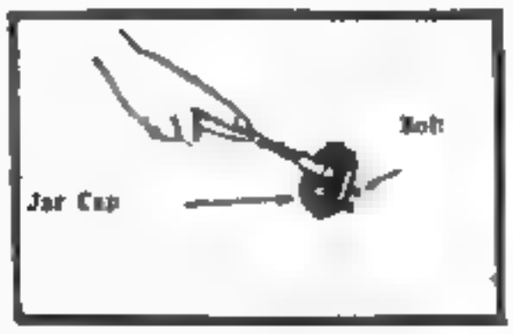
2. Cut a disc from thin metal plate. Disc should fit loosely inside the jar.

NOTE: If metal is painted, rusty or otherwise coated, it must be scraped or sanded to obtain a clean metal surface.



III-31

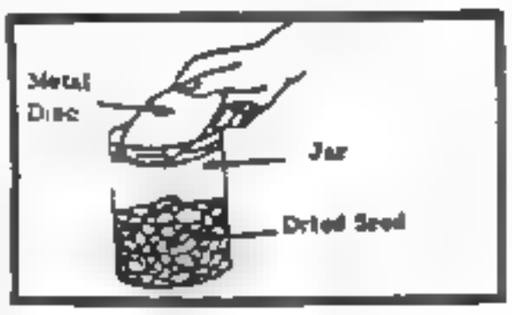
3. Drill two holes in the cap of the jar about 2 inches apart. Diameter of holes should be such that screws or bolts will thread tightly into them. If the jar has a metal cap or no cap, a piece of wood or plastic (NOT METAL) can be used as a cover.



4. Turn the two screws or bolts through the holes in the cap. Bolts should extend about one in. (2 1/2 cm) into the jar.

IMPORTANT: Both bolts must extend the same distance below the container cover

5. Pour dried seeds into the container. The level will depend upon the previously measured rise time and the desired delay.



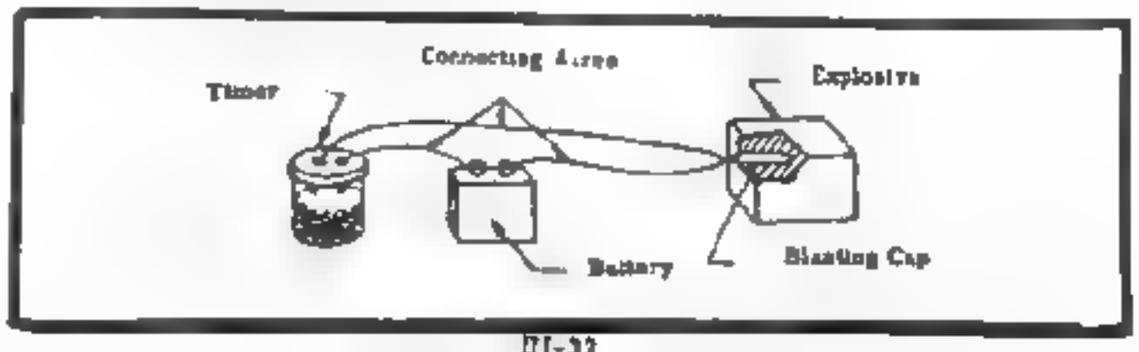
6. Place the metal disc in the jar on top of the seeds.

HOW TO USE:

1. Add just enough water to completely cover the seeds and place the cap on the jar.

2. Attach connecting wires from the firing circuit to the two screws on the cap.

Expansion of the seeds will raise the metal disc until it contacts the screws and closes the circuit.



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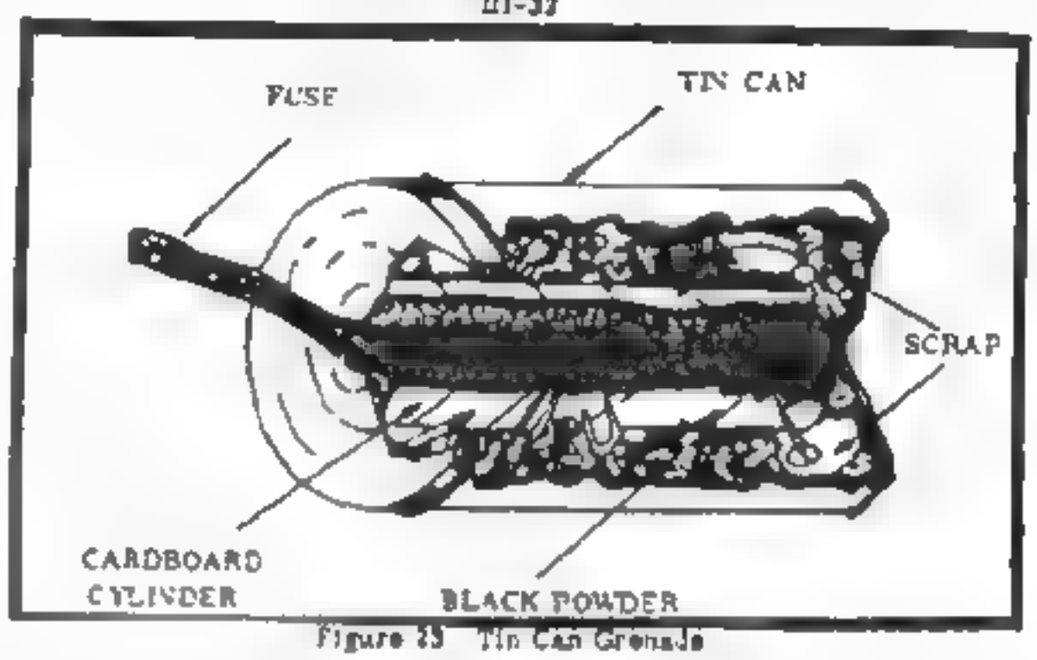


Figure 23 Tin Can Grenade

k. Tin Can Grenade.

Materials Required.

Tin can, jar or similar container.

Bolts, nuts, metal scrap, etc.

Commercial or improvised Black Powder.

Commercial or improvised fuse cord.

Cardboard or heavy paper and tape.

Procedure.

1. Tape cardboard or heavy paper into a cylinder approximately 1/2 the diameter of the tin can or other container.

2. Insert the fuse into one end of this cylinder, pack tightly with black powder and tape the ends closed.

3. Insert the cylinder into the can as shown in Figure 23 and surround with bolts, nuts, metal scrap and/or stones. Close the can with a lid which has a hole in the center for the fuse to pass through. If the container used has no lid, it may be closed with a piece of wood, metal or cardboard of the required size taped in place.

III-33

VIII. CHEMICALS

Chemical	Symbol	Source
Potassium Permanganate	$KMnO_4$	Drug Store, Hospital, Gym
Potassium Chlorate	$KClO_3$	Drug Store, Hospital, Gym
Potassium Nitrate	KNO_3	Fertilizer, Explosive Mfr
Sodium Nitrate	$NaNO_3$	Fertilizer, Glass Mfr
Ammonium Nitrate	$(NH_4)NO_3$	Fertilizer, Explosive Mfr
Ferric Oxide	Fe_2O_3	Hardware or paint store

Powdered Aluminum	AL	Paint store, electric, auto
Magnesium	Mg	Auto Mgfr, Machine, Chemical
Glycerine	$C_3H_5(OH)_3$	Drug Store, Soap, Candle Mgfr
Sulphuric Acid	H_2SO_4	Garage, Machine Shop, Hospital
Sodium Chlorate	$NaClO_3$	Match, Explosive Mgfr, Plant
Sulphur	S	Drug Store, Match Mgfr

IX. Delays.

Cigarette (in match book or box)

Candle (surrounded by inflammable material)

Spark (from short circuited electrical wires)

Sulphuric Acid (sugar chlorate mixture)

Nitrate Acid (sugar chlorate mixture)

Glycerine (sugar permangate mixture)

Water Delay (see diagram)

Watch Delay (see diagram)

III-34

X. DEMOLITION DATA

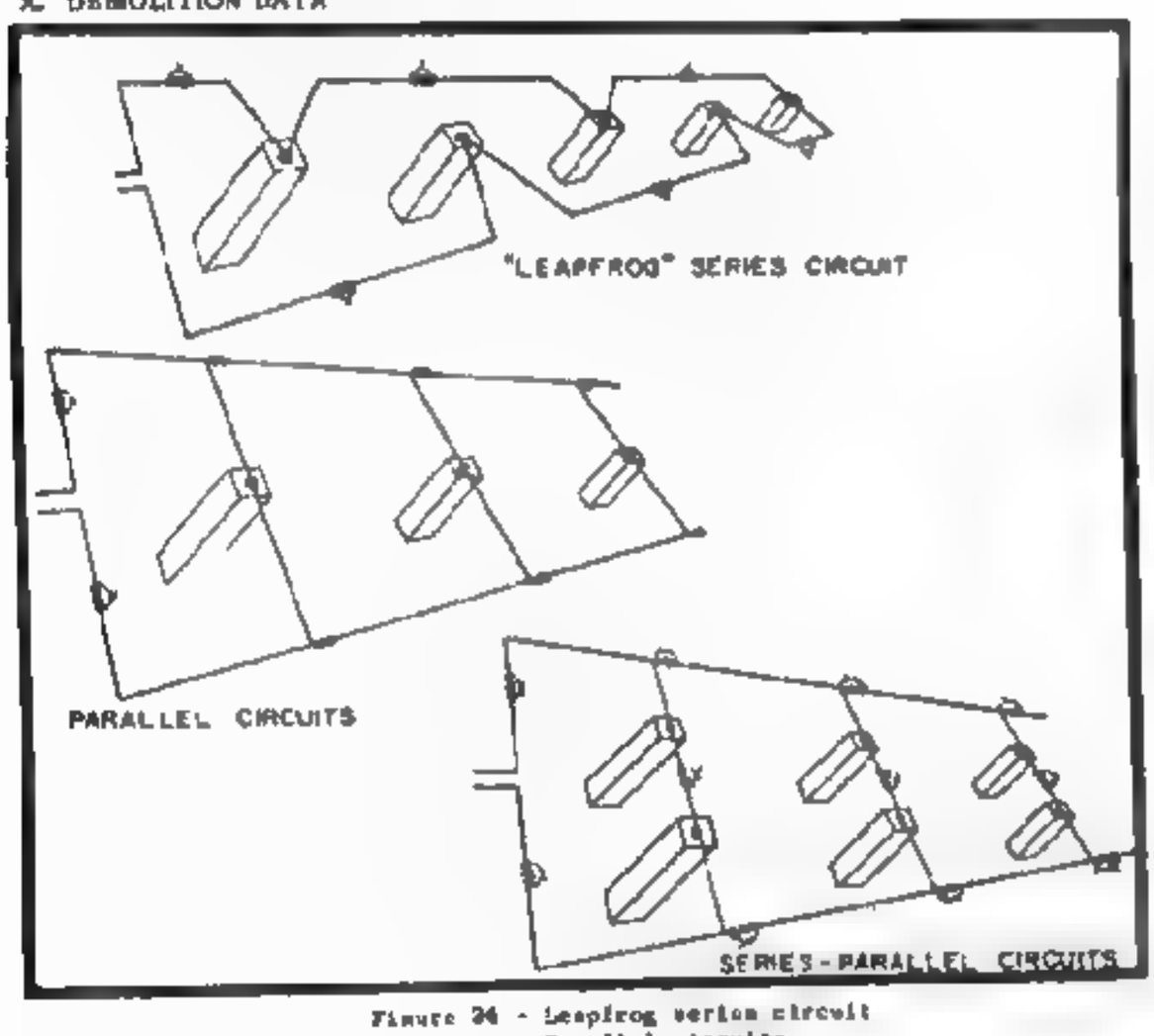


Figure 24 - Leapfrog series circuit
Parallel circuits
Series-parallel circuits

III-35

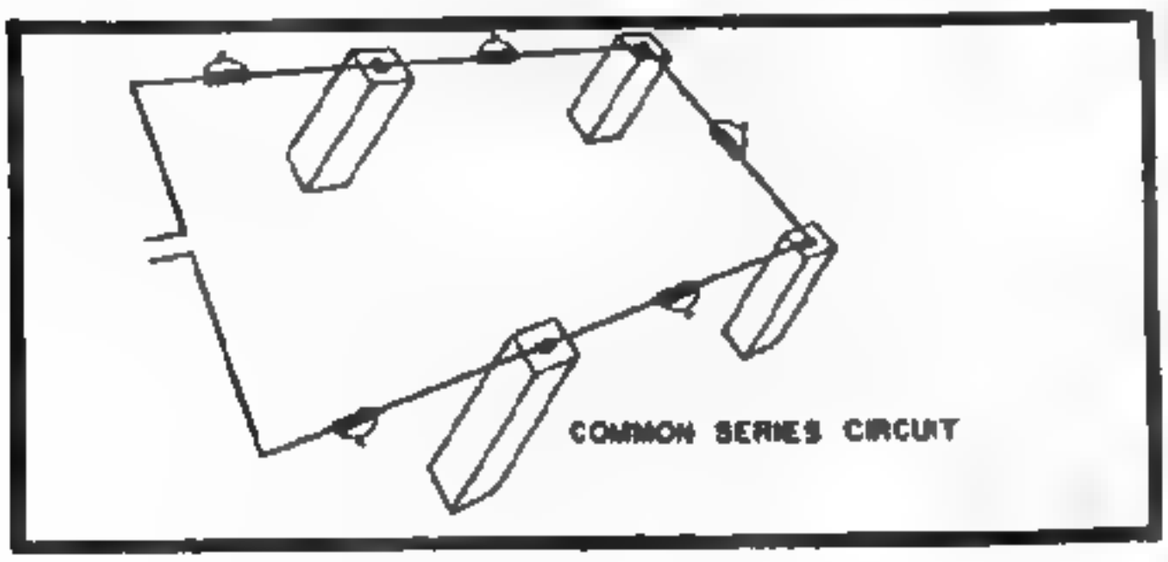


Figure 25. Common series circuit

III-36

Cratering.

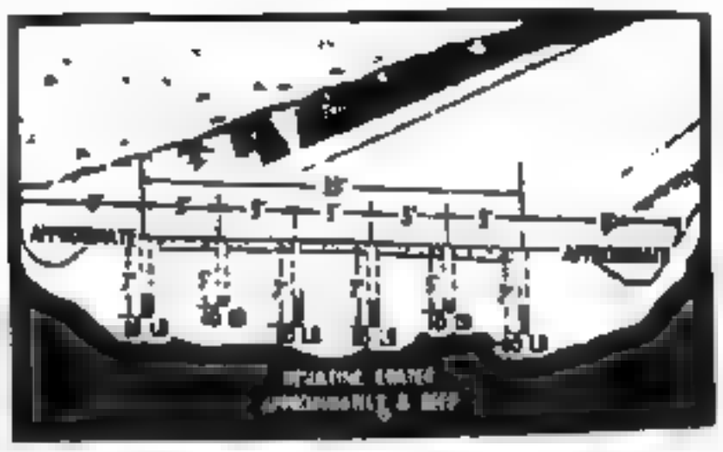


Figure 26 Placement charges for deliberate road crater.

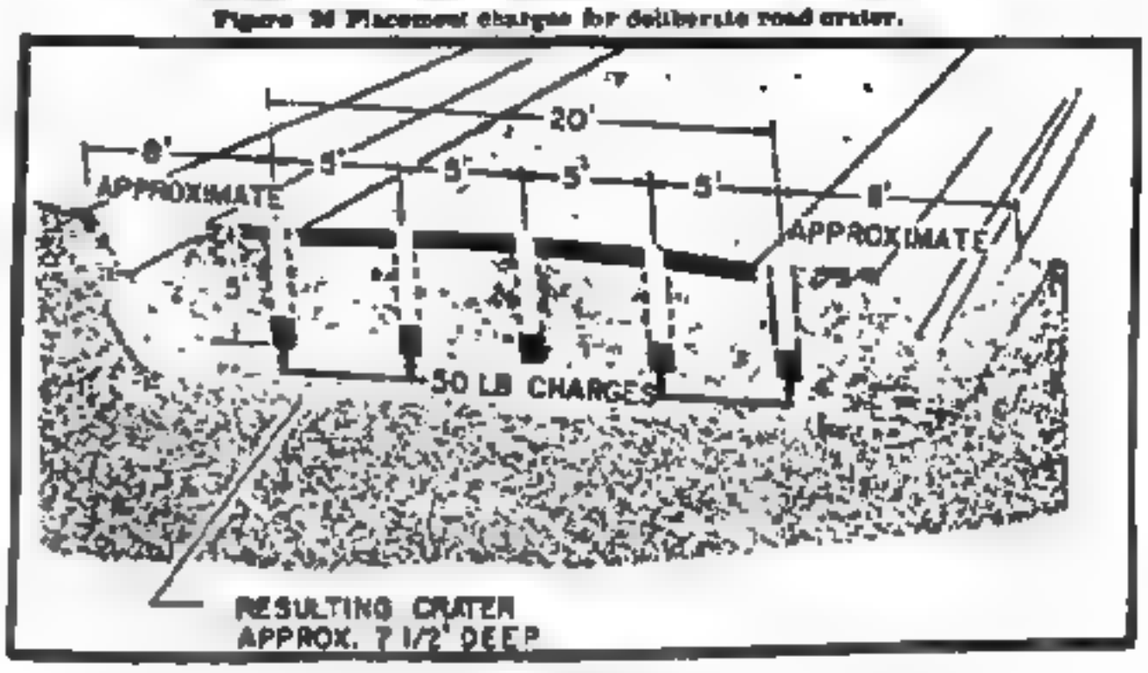


Figure 27 Placement of charges for hasty road crater.

III-37

Bridge Abutment Destruction.

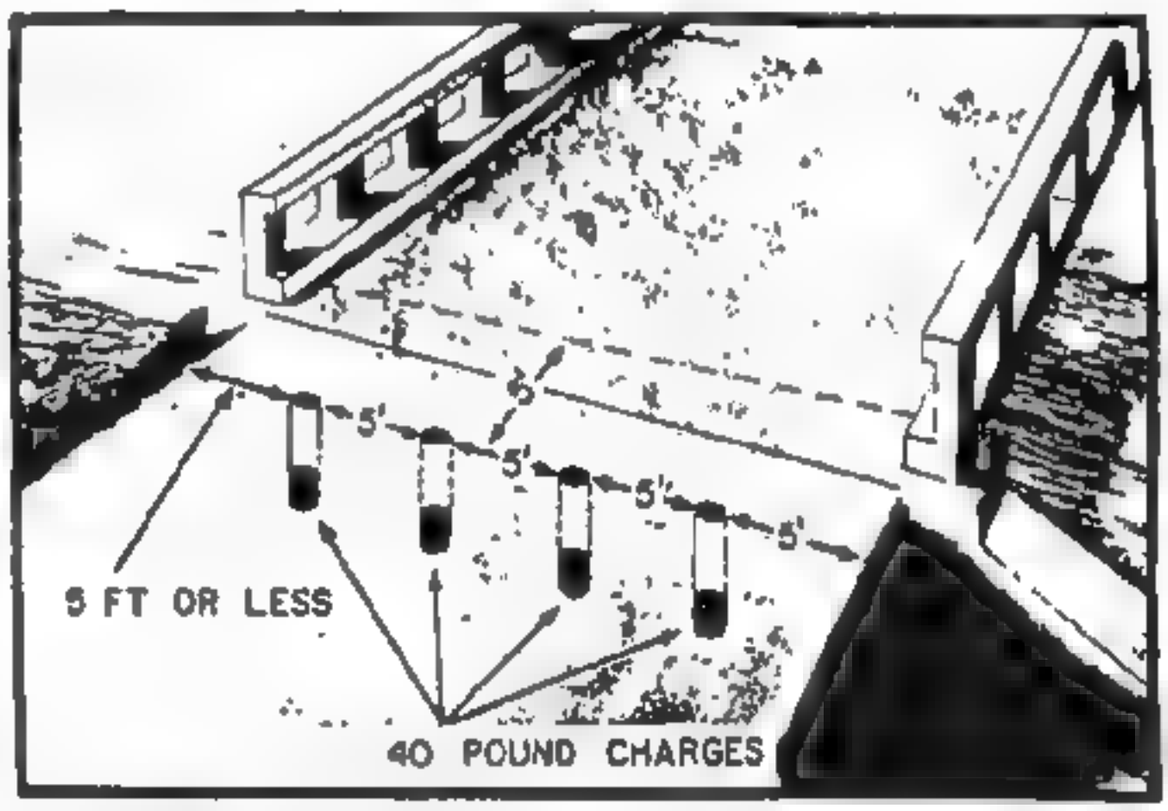


Figure 28 Charges placed in fill behind reinforced concrete abutment 5 feet or less in thickness. (The 5-5-5-40 method)

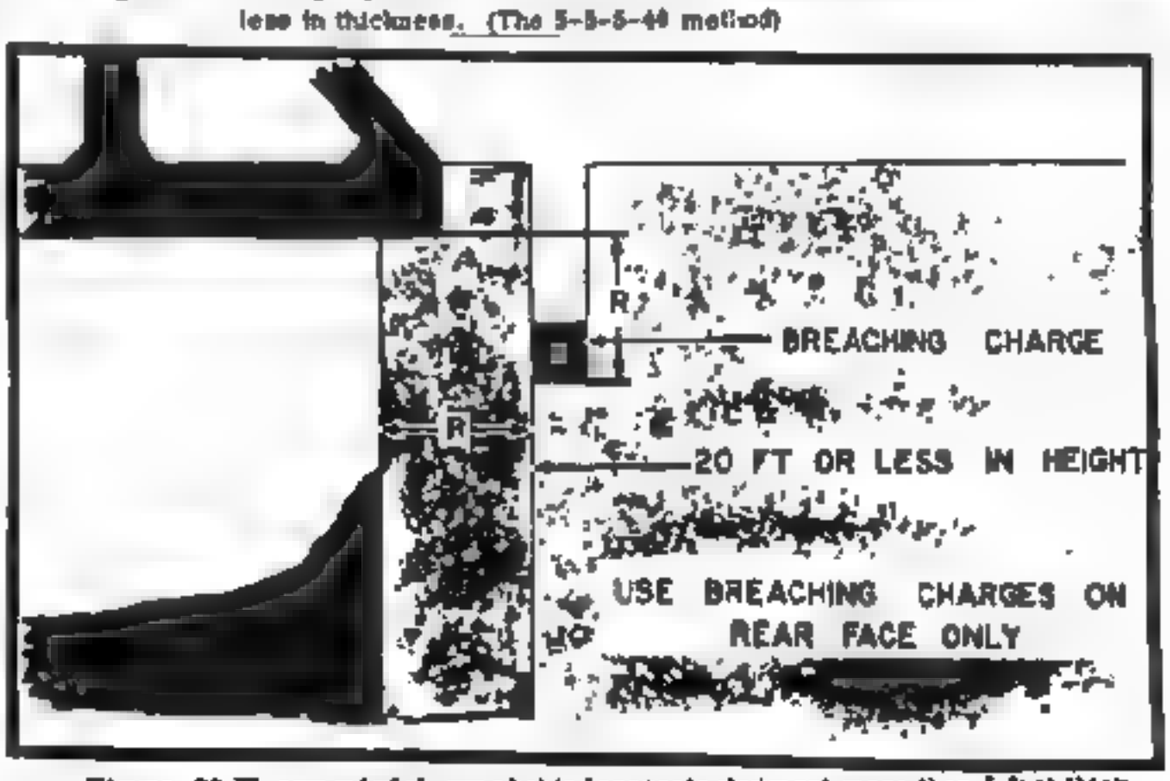


Figure 29 Placement of charges behind concrete abutment more than 5 feet thick.

III-38

NOMENCLATURE OF FIXED BRIDGES

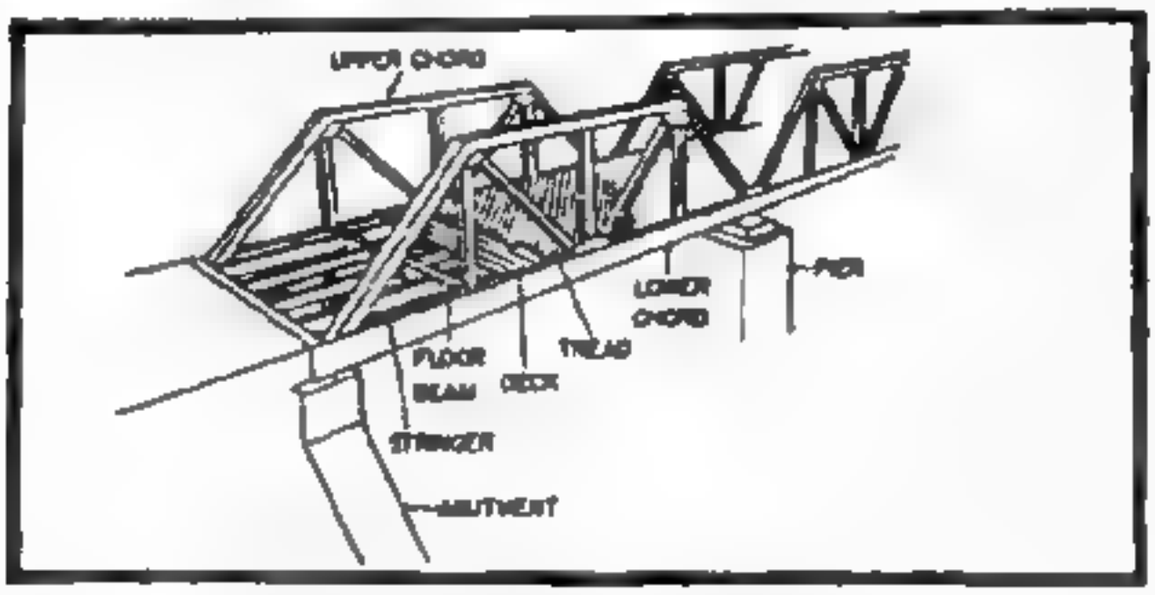


Figure 30 - Parts of fixed bridge

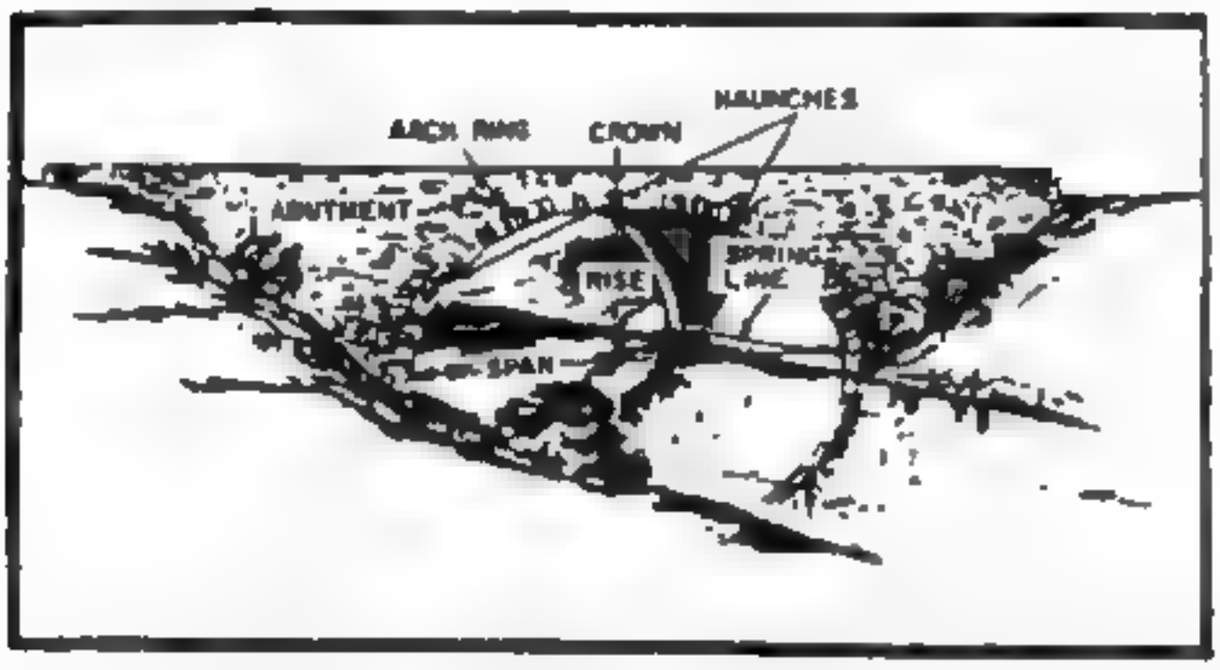


Figure 31 - Arch components

III-39

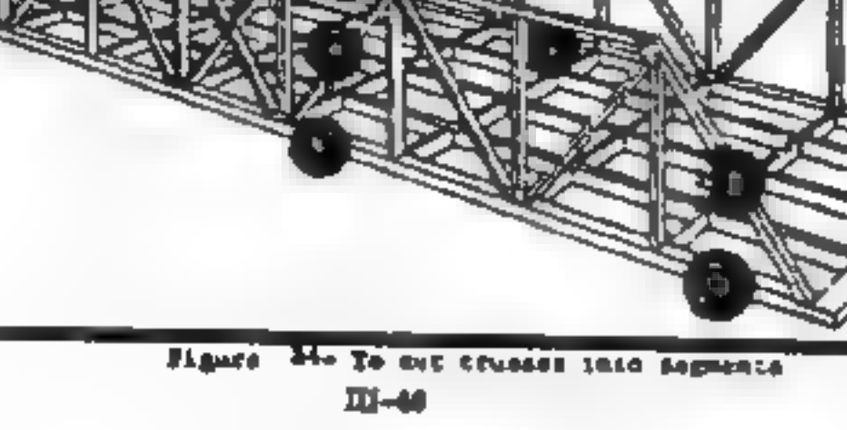


Figure 32 - Steel stringer bridge

Figure 33 - To cut upper and lower chords

Figure 34 - To cut trusses into segments

III-40

DEMOLITION OF CHARGES ON BRIDGES (CONTINUED)

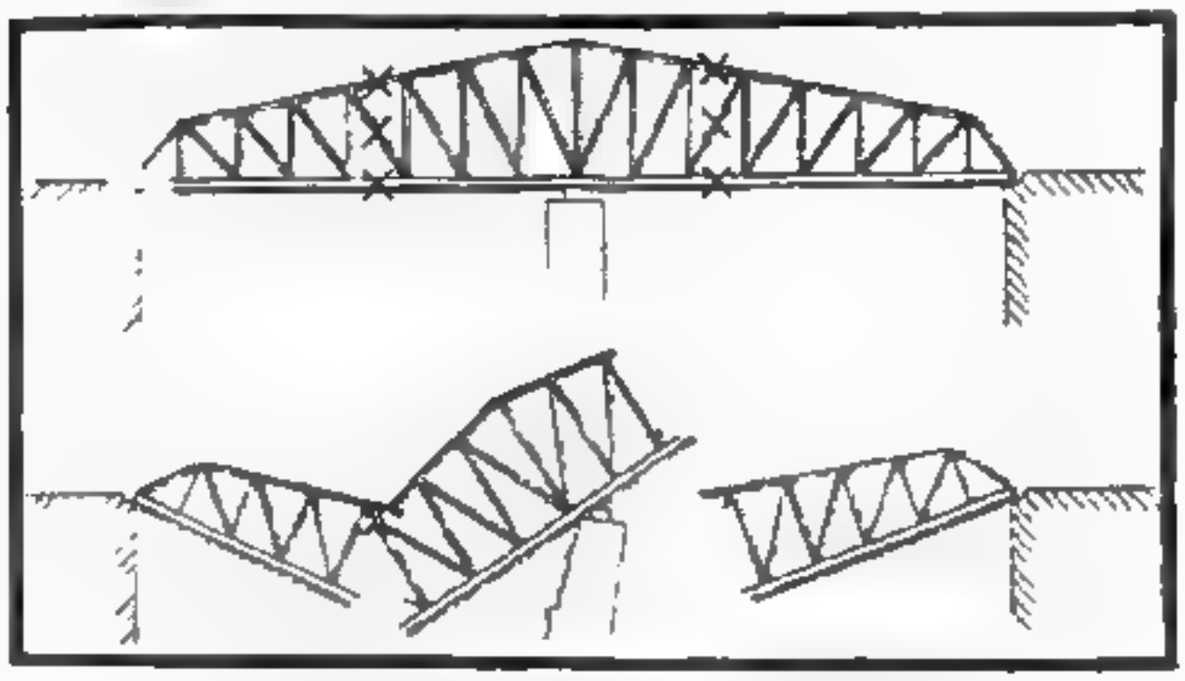


Figure 35 - Continuous span truss

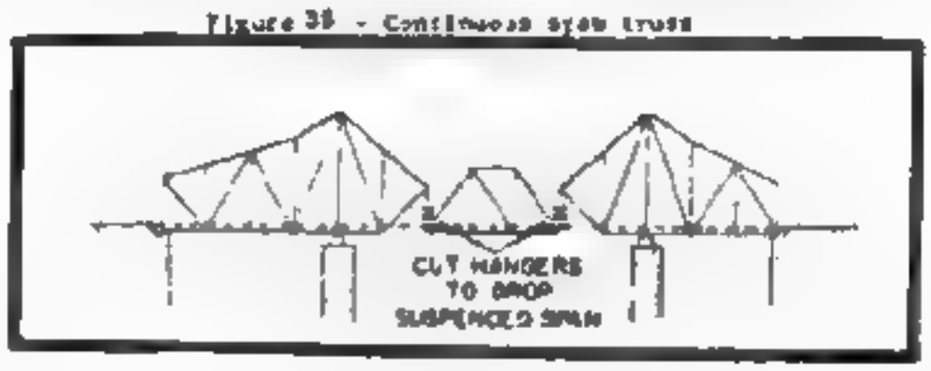


Figure 36 - Cantilever truss with suspended span

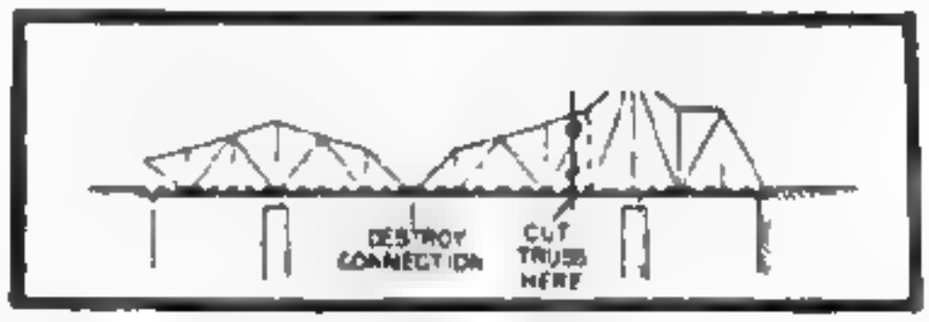


Figure 37 - Cantilever truss without suspended span

III-41

DEMOLITION OF CHARGES ON BRIDGES (CONTINUED)

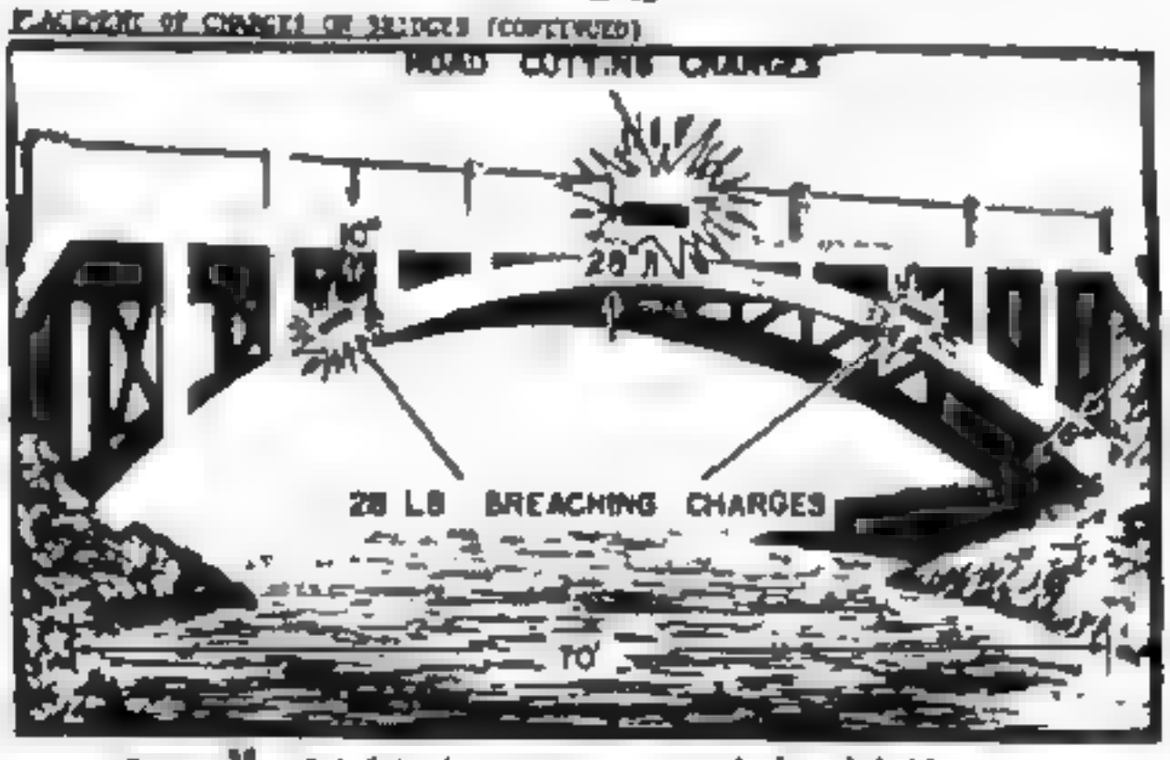


Figure 38 - Reinforced concrete open spandrel arch bridge

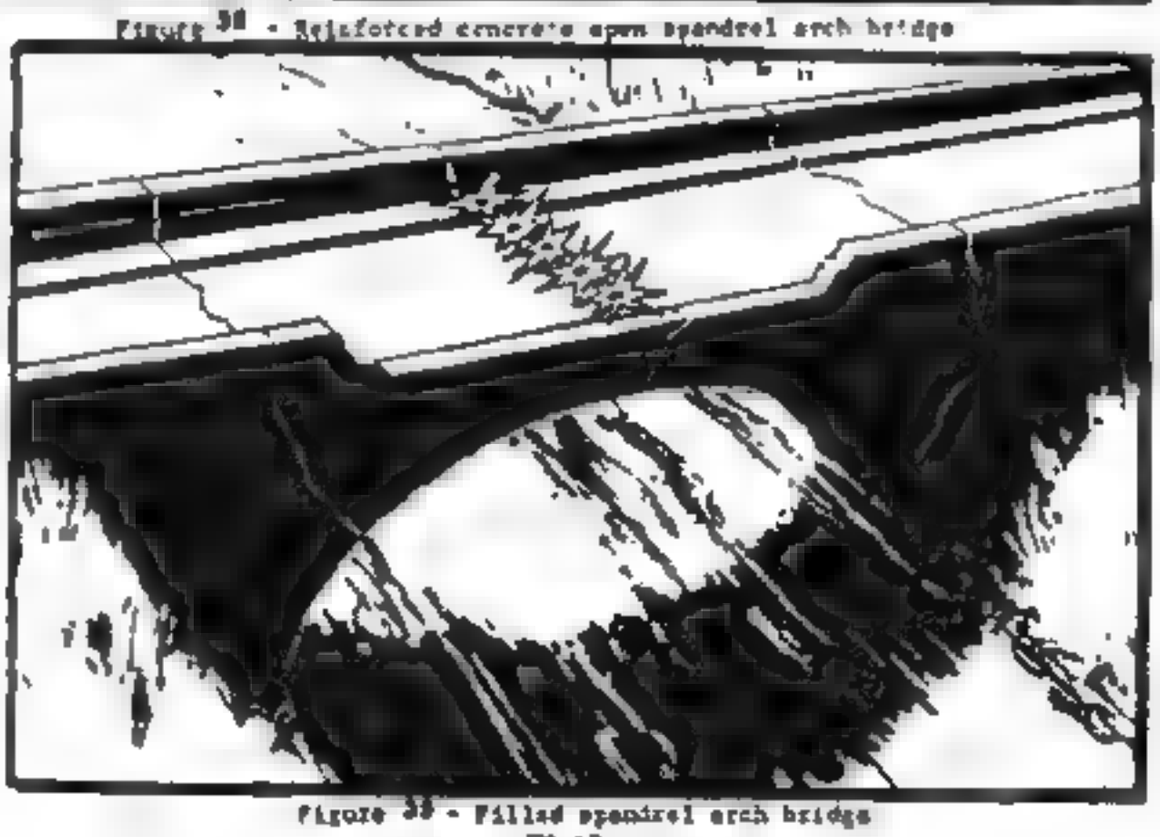


Figure 39 - Filled spandrel arch bridge

III-42

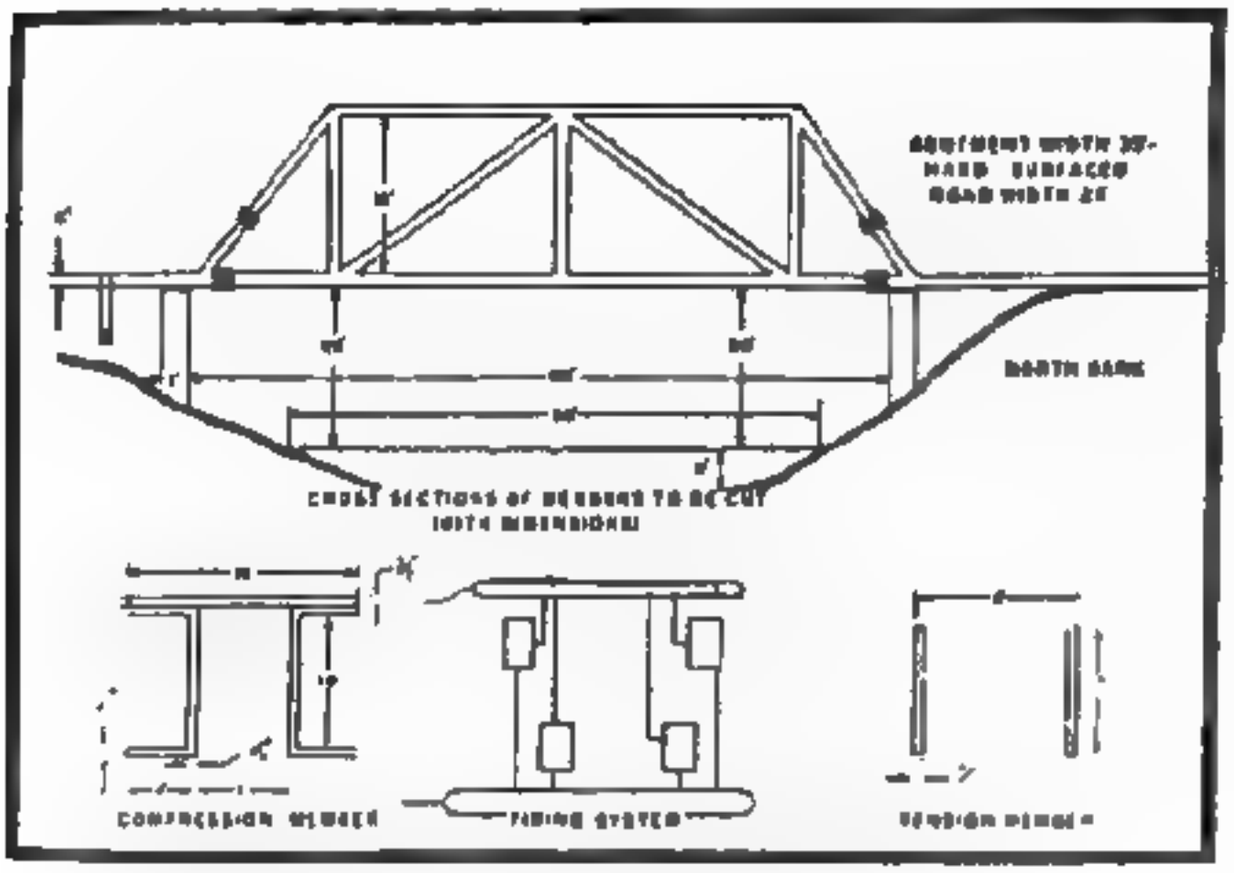


Figure 40

III-43

Route: To and from target areas, approach and withdrawal routes, rallying points, mission support sites, cache sites and final assembly areas may be selected.

Requirements: (Determine availability before recon)

Explosives: _____

Equipment: _____

Personnel: _____

Time: _____

Remarks:

Unusual features of site: _____

Guard system: _____

Labor and time estimate required for bypass or repair:

Sketches: (On reverse side)

Situation map sketch (overhead view): Magnetic north, principal terrain concealment, avenues of approach to target, direction of enemy, etc.

Line drawing of target (side or angle view): Critical over-all dimensions and placement of charges.

Cross sections of members to be cut (cut-away view): exact dimensions.

III-45

SITUATION MAP SKETCH

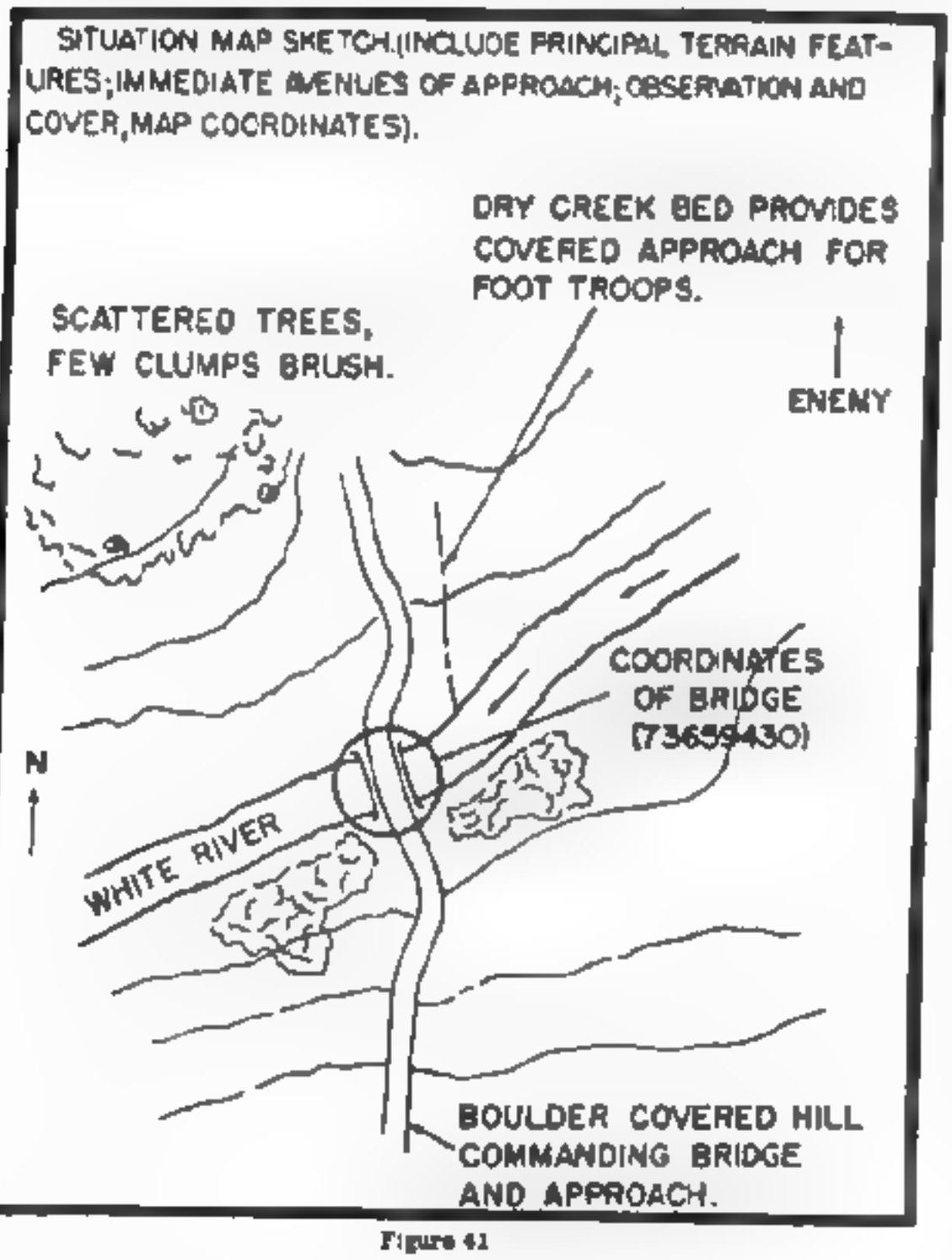


Figure 41

III-44

XI. TARGET RECONNAISSANCE REPORT GUIDE.

Target: _____

Location: _____

Times Observed: _____

General Description: _____

Proposed Action: _____

CHAPTER 4
AIR OPERATIONS

I. PREPLANNED AIR RESUPPLY OPERATIONS:

a. Automatic Resupply Plan. This plan provides for initial automatic replacement of essential equipment and supplies, primarily communications equipment, immediately after infiltration.

(1) Preinfiltration planning includes: DZ selection, DZ markings, drop time and date, and supplies to be dropped.

(2) Immediately after infiltration provide for replacement of essential equipment and supplies, particularly communications equipment.

(3) The automatic resupply plan may be received as planned, modified, or may be cancelled after infiltration, once contact is established with the SFOB.

(4) If the detachment fails to contact the SFOB after infiltration, the drop is executed as preplanned.

b. Emergency Resupply Plan. This plan provides for emergency replacement of supplies and equipment essential to individual survival, communications, and combat throughout the time that the detachment is in the operational area.

(1) Preinfiltration planning includes: provisional DZ selection to be confirmed after infiltration, DZ markings, drop date and time based upon the emergency, and supplies to be dropped.

(2) After infiltration is completed and communications established with the SFOB, the emergency DZ location (which is known only to the special forces detachment members) is either confirmed or a new location is designated.

(3) The preplanned emergency resupply drop is normally executed after the detachment misses a specified, consecutive number of scheduled communications contacts.

II. DROP ZONES:

a. General. The selection of a DZ must satisfy the requirements of both the aircrew and the reception committee. The aircrew must be able to locate and identify the DZ. The reception committee selects a site that is accessible, reasonably secure, and permits safe delivery of incoming personnel and/or supplies.

IV-1

Air considerations.

(1) Desirable terrain features.

(a) The general area surrounding the site must be relatively free from obstacles which may interfere with safe flight.

(b) Flat or rolling terrain is desirable; however, in mountainous or hilly country, sites selected at higher elevations such as level plateaus can be used.

(c) Small valleys or pockets completely surrounded by hills are difficult to locate and should not normally be used.

(d) In order to afford the air support unit flexibility in selecting the IP, it is desirable that the aircraft be able to approach the target site from any direction.

(e) There should be an open approach quadrant of at least 90° to allow the aircrew a choice when determining their approach track from the IP.

(f) DZ's having a single clear line of approach are acceptable for medium aircraft, provided: a) a level turning radius of 3 miles (5 kilometers) on each side of the site [illegible] or 1.5 kilometers for light aircraft (Figure 1).

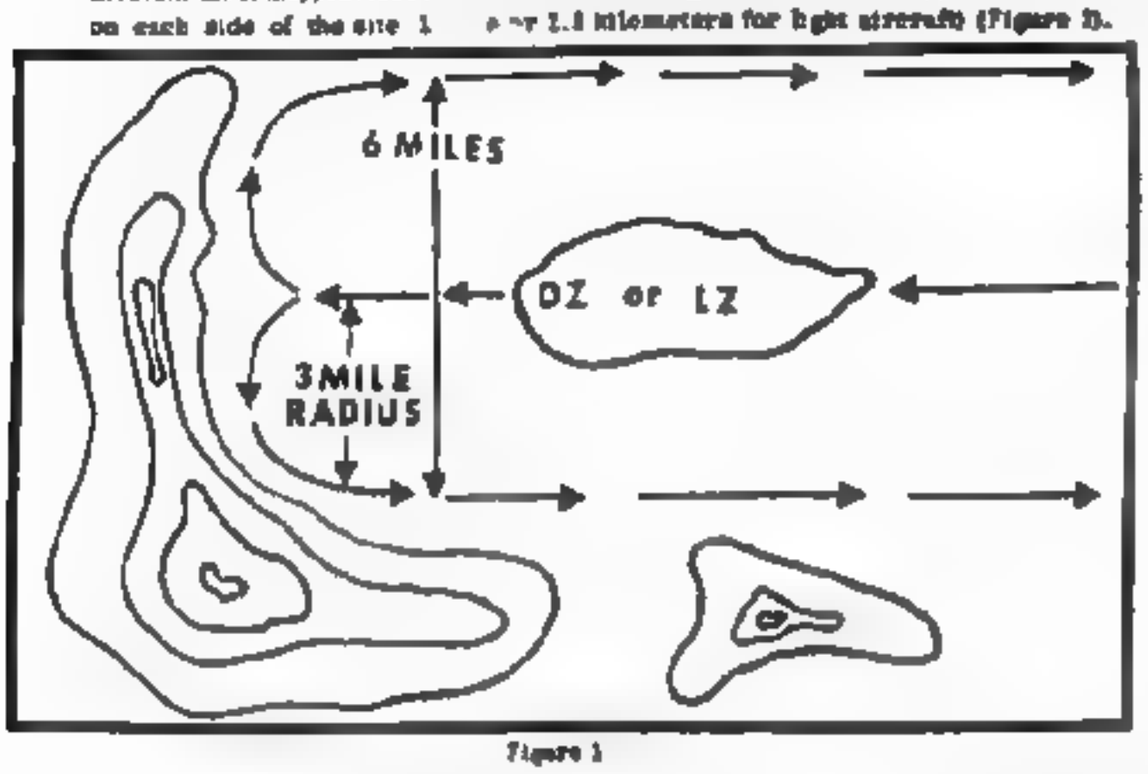


Figure 1

IV-2

(g) Rising ground or hills of more than 1,000 feet (303 meters) elevation above the surface of the site should normally be at least 10 miles from DZ for night operations. In exceptionally mountainous areas deviations from this requirement may be made. Any deviation will be noted in the DZ report.

(h) Deviations from the aforementioned minimum distances cause the aircraft to fly at higher than desirable altitudes when executing the drop.

(2) Weather in drop areas. The prevailing weather conditions in the area must be considered. Ground fogs, mists, haze, smoke, and lowhanging cloud conditions may interfere with visual signals and DZ markings. Excessive winds also hinder operations.

(3) Obstacles. Due to the low altitudes at which operational drops are conducted, consideration must be given to navigational obstacles in excess of 300 feet (90 meters) above the level of the DZ and within a radius of 3 miles (5 kilometers). If such obstacles exist and are not shown on the issued maps, they must be reported.

(4) Enemy air defenses. Drop sites should be located so as to preclude the aircraft flying over or near enemy air installations when making the final approach to the DZ.

c. Ground Considerations.

(1) Shape and size.

(a) The most desirable shape for a DZ is square or round. This permits a wider choice of aircraft approach directions than is normally the case with rectangular-shaped sites.

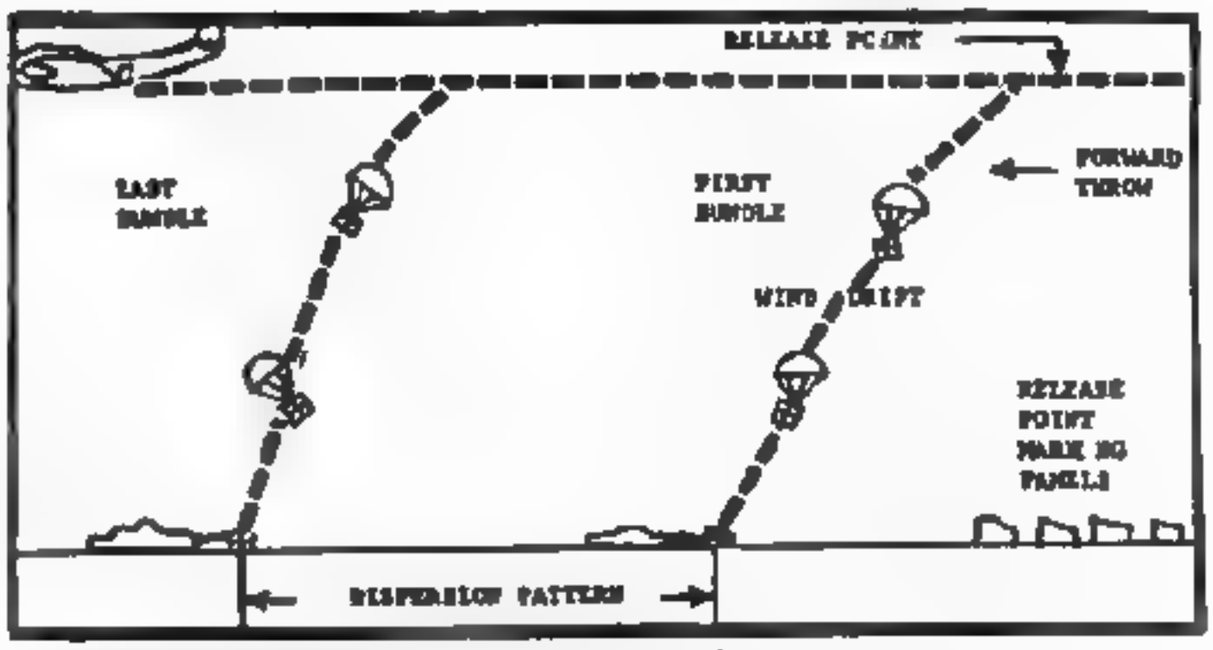
(b) The required length of a DZ depends primarily on the number of units to be dropped and the length of their dispersion pattern.

1. Dispersion occurs when two or more personnel or containers are released consecutively from an aircraft in flight. The long axis of the landing pattern is usually parallel to the direction of flight (Figure 2).

IV-3

2. Dispersion is computed using the rule-of-thumb formula: 1/2 speed of aircraft (knots) x exit time (seconds) = dispersion (meters). Exit time is the elapsed time between the exits of the first and last items.

3. The length of the dispersion pattern represents the absolute minimum length required for DZ's. If personnel are to be dropped, a safety factor of at least 100 meters is added to each end of the DZ site.



Length of dispersion patterns in meters equals 1/2 aircraft speed (in knots) times exit time (in seconds).

Figure 2. Computation of Dispersion

(c) The width of rectangular-shaped DZ's should allow for minor errors in computation of wind drift.

(d) The use of DZ's measuring less than 800 x 800 meters should be avoided.

IV-4

(2) Surface.

(a) The surface of the DZ should be reasonably level and free from obstructions such as rocks, trees, fences, etc. Tundra and pastures are types of terrain which are ideal for both personnel and cargo reception.

(b) Personnel DZ's located at comparatively high elevations (6,000 feet (1,840 meters) or higher) should, where possible, utilize soft snow or grasslands, due to the increased rate of parachute descent.

(c) Swamps and low marshy ground, normally less desirable in the summer, and paddy fields when dry often make good drop zones.

(d) Personnel and cargo can be received on water DZ's.

1. Minimum depths for reception of personnel is 4 feet and arrangements must be made for rapid pickup.

2. The surface of the water must be clear of floating debris or moored craft, and there should be no protruding boulders, ledges, or pilings.

3. The water must also be clear of underwater obstructions to a depth of 4 feet.

4. Water reception points should not be near shallows or where currents are swift.

5. Minimum safe water temperature is 60°F. (16°C).

(e) Supply drop zones may, in general, utilize any of the following types of surfaces:

1. Surfaces containing gravel or small stones no larger than a [illegible]

2. Agricultural ground, although in the interest of security, it is [illegible]

3. Sites containing brush or even tall trees; however, marking of the DZ and the recovery of containers is more difficult.

IV-5

4. Marsh, swamp, or water sites, provided the depth of water or growth of vegetation will not result in loss of containers.

(f) Ground Security. The basic considerations for ground security are that the DZ be:

(a) Located to permit maximum freedom from enemy interference.

(b) Isolated or in a sparsely populated area.

(c) Accessible to the reception committee by concealed approach and [illegible]

(d) Adjacent to areas suitable for the caching of supplies and disposition of aerial delivery equipment.

III. REPORTING DROP ZONES:

a. Drop Zone Data. The minimum drop zone data which is reported includes:

(1) Code name. Extracted from the SOI, also, indicate if primary or alternate DZ.

(2) Location. Complete military grid coordinates of the center of the DZ.

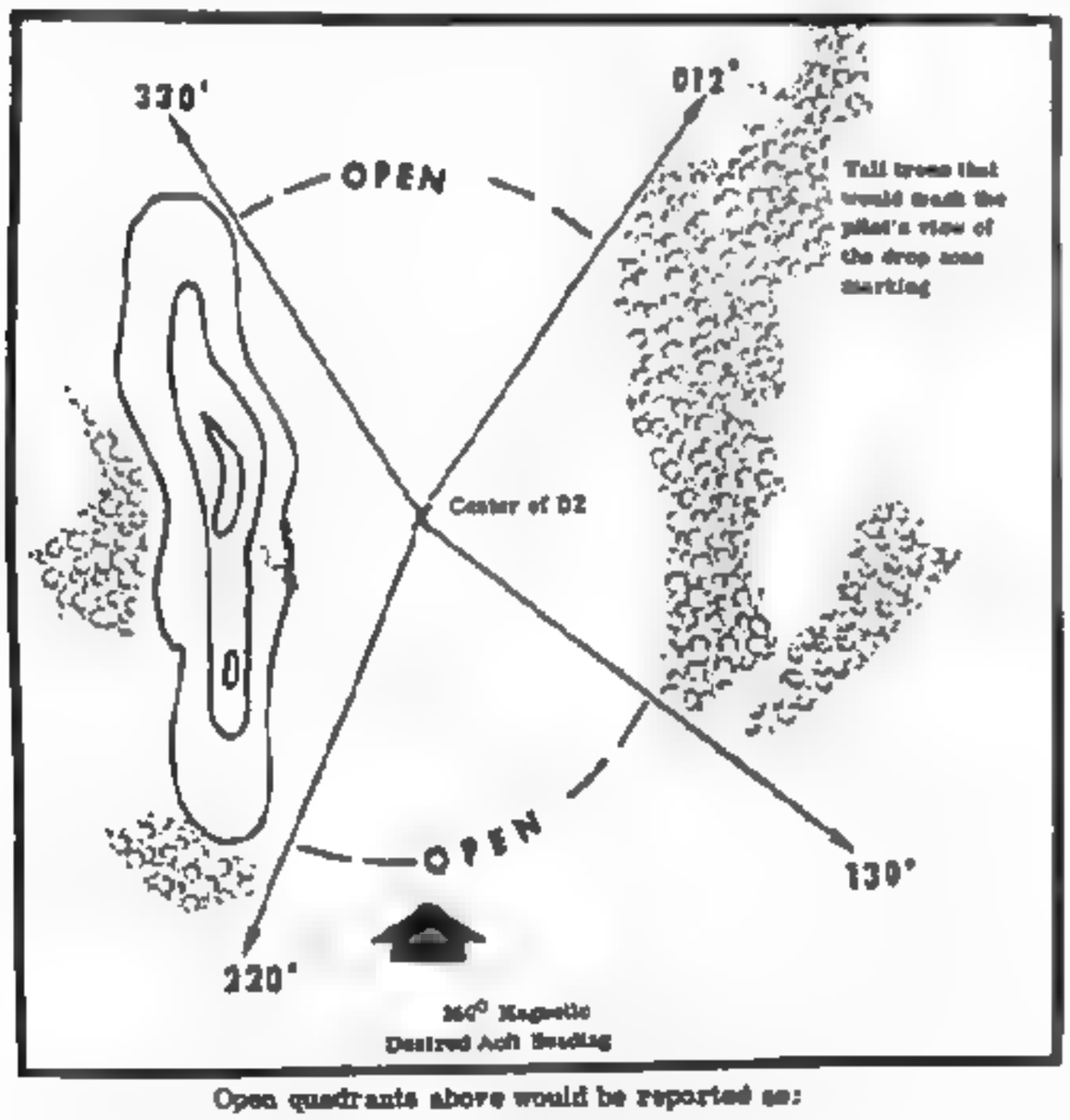
(3) Open Quadrant. Measured from center of DZ, reported as a series of magnetic azimuths. The open quadrant indicates acceptable aircraft approaches (Figure 3).

(4) Track. Magnetic azimuth of required or recommended aircraft approaches (Figure 3).

(5) Obstacles. Those that are over 300 feet (90 meters) in elevation above the level of the DZ, within a radius of ½ miles (8 kilometers) and which are not shown on the issued maps. Obstacles are reported by description, magnetic azimuth, and distance from the center of the DZ (Figure 4).

(6) Reference point. A landmark shown on the issued maps, reported by name, magnetic azimuth and distance from the center of the DZ (Figure 4). Used with (2) above in plotting the DZ location.

IV-6



Open quadrants above would be reported as:

OPEN 130 to 220 AND 330 to 012 DEG

Figure 3 Computation of Open Quadrant

IV-7

(7) Date/time drop requested.

(8) Items requested. Extracted from the catalog supply system.

b. Additional Items. In special situations, additional items may be required, e.g., additional reference points, navigational check points in the vicinity of the DZ, special recognition and authentication means. Sub-paragraphs (7) and (8) above are included only when requesting a resupply mission in conjunction with the reporting of the DZ.

c. Azimuths. Azimuths are reported as magnetic and in three digits. With the exception of the aircraft track, all azimuths are measured from the center of the DZ. Appropriate abbreviations are used.

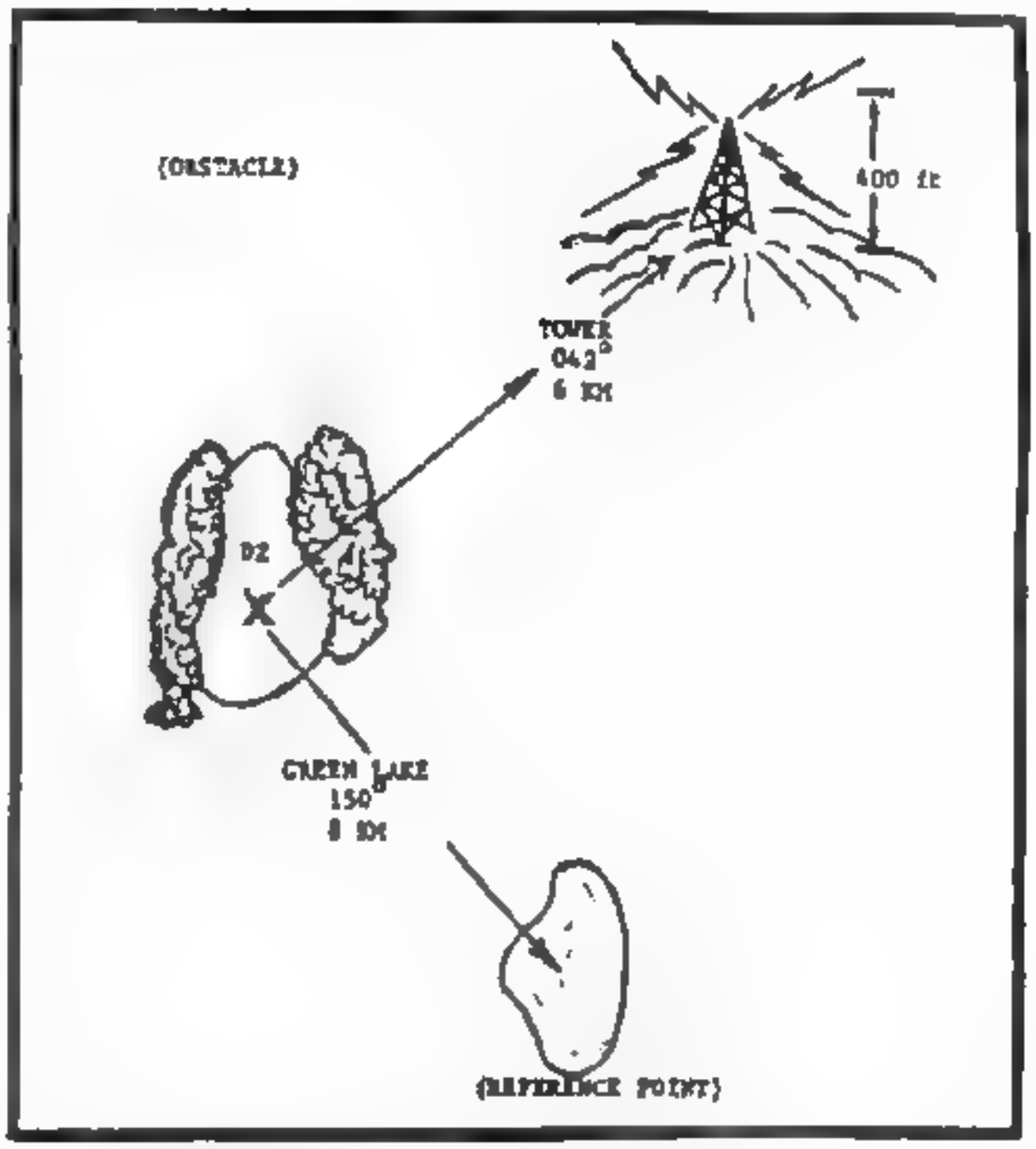


Figure 4. Reporting obstacles and reference points

IV-8

d. Initial Points (IP's). It is desirable to reconcile the requested aircraft track with an identifiable landmark that may be used by the aircrew as an initial point (IP). The IP, located at a distance of 5 to 15 miles (8-24 kilometers) from the DZ, is the final navigational checkpoint prior to reaching the target. Upon reaching the IP, the pilot turns to a predetermined magnetic heading that takes him over the DZ within a certain number of minutes (Figure 5). The following features constitute suitable IP's:

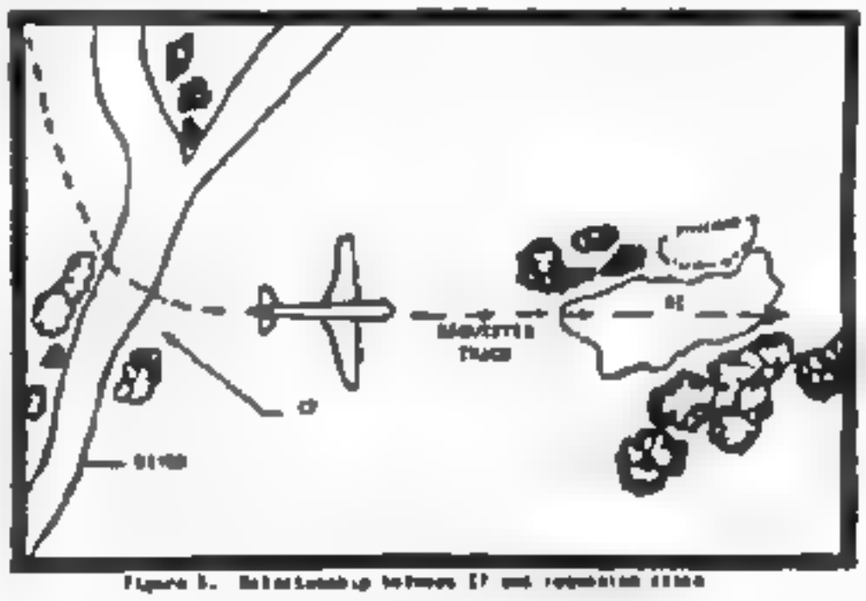


Figure 5. Relationship between IP and reference time

IV-9

(1) Coastlines. A coastline with breaking surf is easily distinguished at night. Mouths of rivers over 50 yards wide, sharp uprisings, and inlets are excellent guides for both day and night.

(2) Rivers and canals. Wooded banks reduce reflections, but rivers more than 50 yards wide are visible from the air. Canals are easily recognizable from their straight banks and uniform width. Small streams are not discernible at night.

(3) Lakes. Lakes at least one-half mile (1 kilometer) square give good light reflection.

(4) Forest and woodlands. Forested areas at least one-half mile square with clearly defined boundaries of unmistakable shape.

(5) Major roads and highways. Straight stretches of main roads with one or more intersections. For night recognition, dark surfaced roads are not desirable as IP's although when the roads are wet, reflection from moonlight is visible.

IV. MARKING DROP ZONES:

a. Purpose. The purpose of DZ markings is to identify the site for the aircrew and to indicate the point over which the personnel and/or cargo should be released (release point). The procedures for marking DZ's are determined prior to infiltration and are included in the SOI.

b. Equipment.

(1) The marking of DZ's at night during clandestine operations will normally be only by flashlights. Flashlights manufactured in the country are easily procured by the guerrillas, give adequate directional lighting when properly held, and are not incriminating when found by the security forces on the person of a member of the resistance force. In rare instances other possible lighting devices such as flares, flarepots, fuses, or small wood fires may be used.

(2) For daylight operations a satisfactory method is the use of issued Panel Marking Set AP-50 or VS-16. If issued panels are not available, sheets, strips of colored cloth or other substitutes may be issued as long as there is a sharp contrast with the background. Smoke signals, either smoke grenade or

simple smudge fires, greatly assist the aircrew in sighting the DZ markings on the approach run.

(3) The use of electronic homing devices permits the conduct of reception operations during conditions of low visibility. Such devices normally are used in conjunction with visual marking systems.

c. Computation of Release Point. The release point must be determined to insure delivery of personnel and/or cargo within the usable limits of the DZ. Computation of the release point involves the following factors (Figure 6).

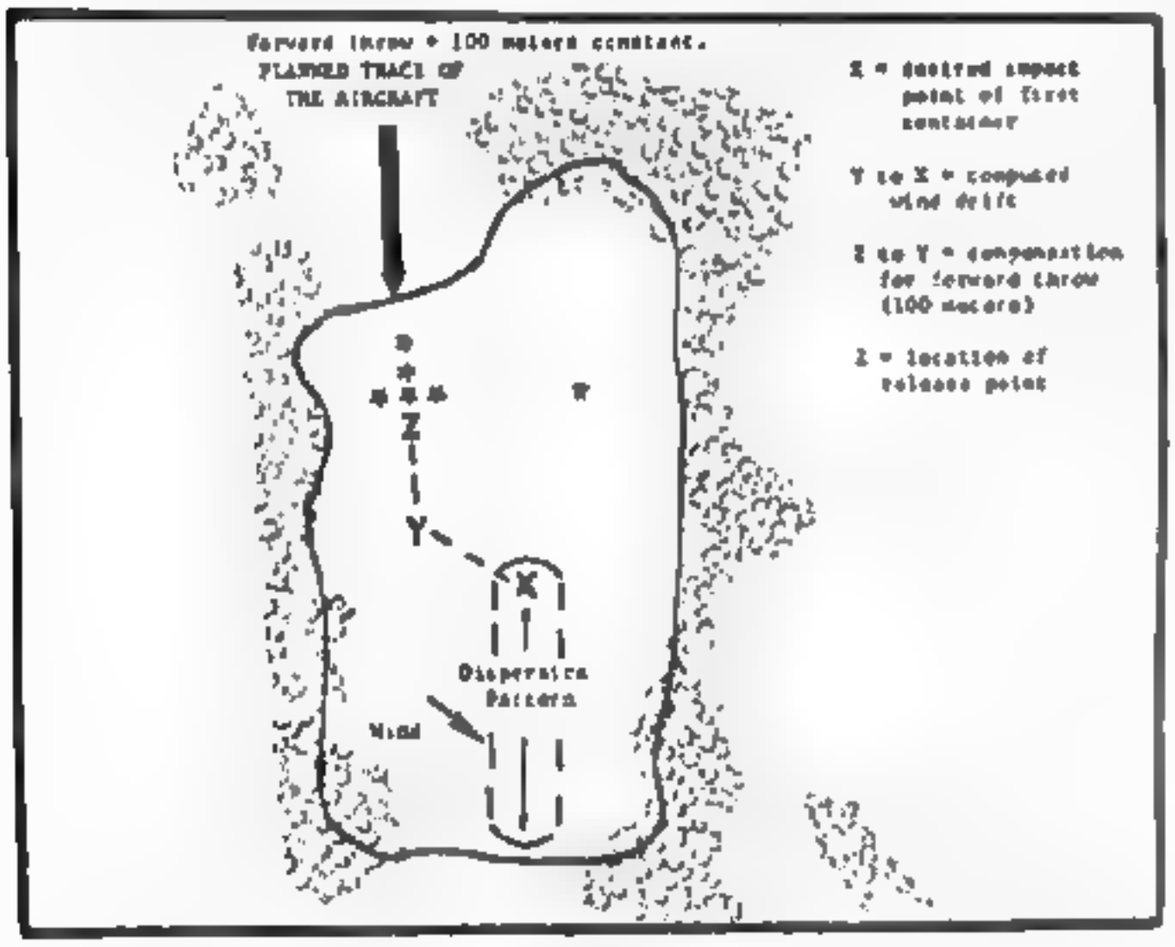


Figure 6

(1) Personnel from low velocity cargo drops.

(a) Dispersion. Dispersion is the length of the pattern formed by the exit of the parachutists and/or cargo containers (Figure 2). The desired point of impact for the first parachutist/container depends upon the calculated dispersion.

(b) Wind drift. This is the horizontal distance traveled from the point of exit to the point of landing as a result of wind conditions. The release point is located an appropriate distance upwind from the desired impact point. To determine the amount of drift, use the following formulas:

1. For personnel using the T-10 parachute: Drift (meters) = altitude (hundred of feet) x wind velocity (knots) x 4.1 (constant factor).

2. For all other low velocity parachute drops: Same as 1 above, however, substitute a constant factor of 2.6 for 4.1.

NOTE: Where no mechanical wind velocity indicator is available, the approximate velocity can be determined by dropping bits of paper, leaves, dry grass, or dust from the shoulder and pointing to the dry place where they land. The estimated angle in degrees formed by the arm with the body, divided by 4, equals wind velocity.

(c) Forward throw. This is the horizontal distance traveled by the parachutist or cargo container between the point of exit and the opening of the parachute. This factor, combined with reaction time of personnel in the aircraft, is compensated for by moving the release point an additional 100 meters in the direction of the aircraft approach (Figure 6).

High velocity and free-drops. Due to their rapid rate of descent, high velocity and free-drop loads are not materially affected by wind conditions. Otherwise, the factors of dispersion and forward throw are generally similar to those for personnel and low velocity drops and are compensated for in the same manner.

d. Methods of Release Point Marking. There are two methods for marking the DZ release point. The principal difference between the two is the method of providing identification. The marking systems described below are designed primarily for operational drops executed at an absolute altitude of 800 feet (155 meters). Training jumps executed at an absolute altitude of 1,250 feet (385 meters) require a modification of the marking systems.

1. Training jumps conducted at an absolute altitude of 1,250 feet (385 meters) require the use of a flank panel or light placed 200 meters to the left of the release point markings. The configuration of present cargo and troop carrying aircraft prevents the pilot from seeing the markings after approaching within approximately one (1) mile of the DZ while flying at 1,250 feet (385 meters) absolute altitude. From this point on, the pilot must depend on flying the proper track in order to pass over the release point. The flank marker serves to indicate when the aircraft is over the release point and the exact moment the drop should be executed. Operational drops executed at 800 feet (155 meters) absolute altitude do not require the flank panel because the pilot does not lose sight of the markings as he approaches the DZ. (See Figure 7)

2. Operational personnel drops or supply drops within a GWOA will normally be executed at altitudes between 600-800 feet for personnel and 400-600 feet for supplies. Release point markings are different numbers of lights with different configurations for each 24-hour period. The exact number of lights and the exact configuration is determined by the detachment SOI. (See Figure 8)

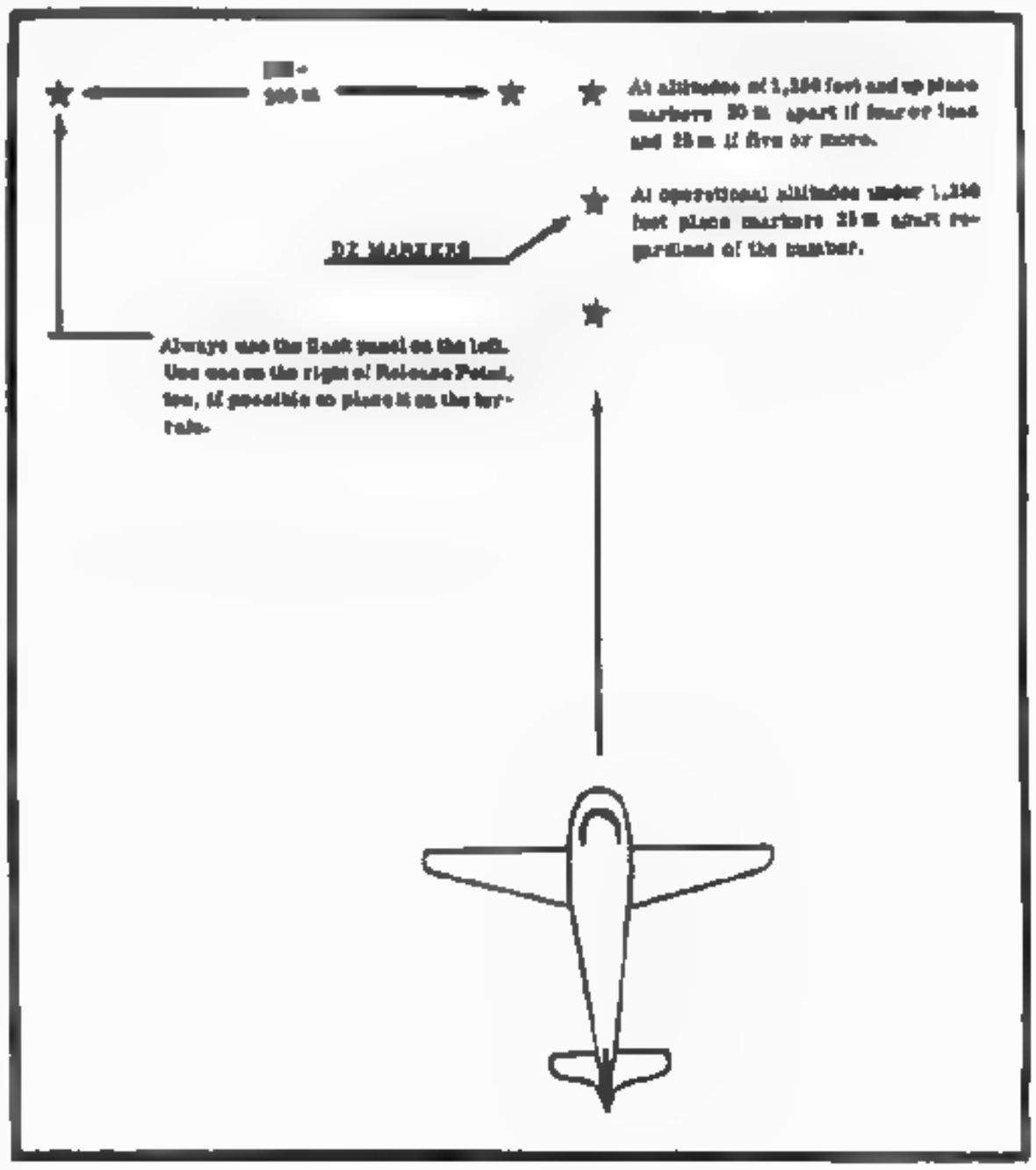


Figure 7. Methods of release point marking

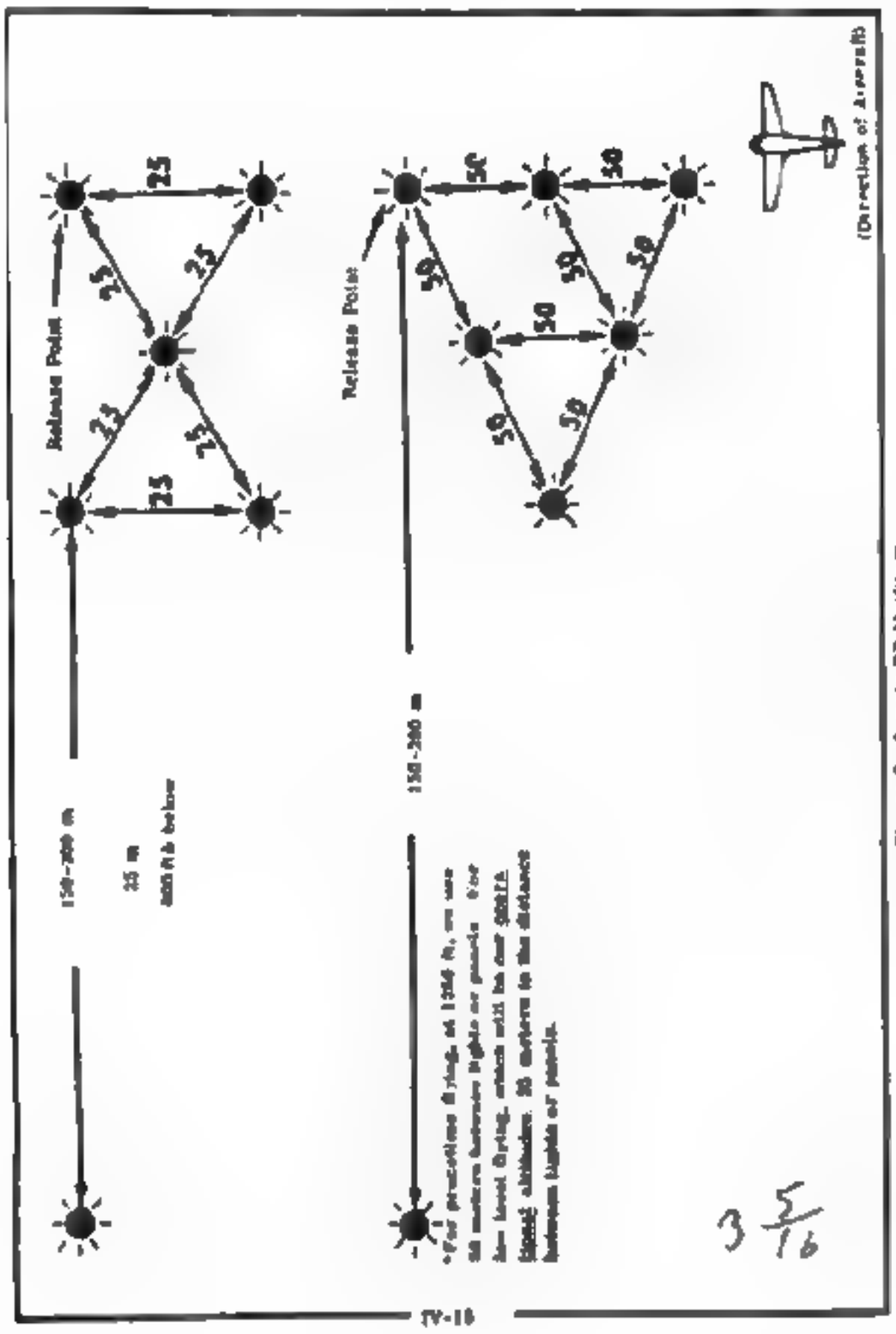


Figure 8. Sample DZ Markings
(Obstructive Configuration, not necessarily a known

FM-18

3 5/16

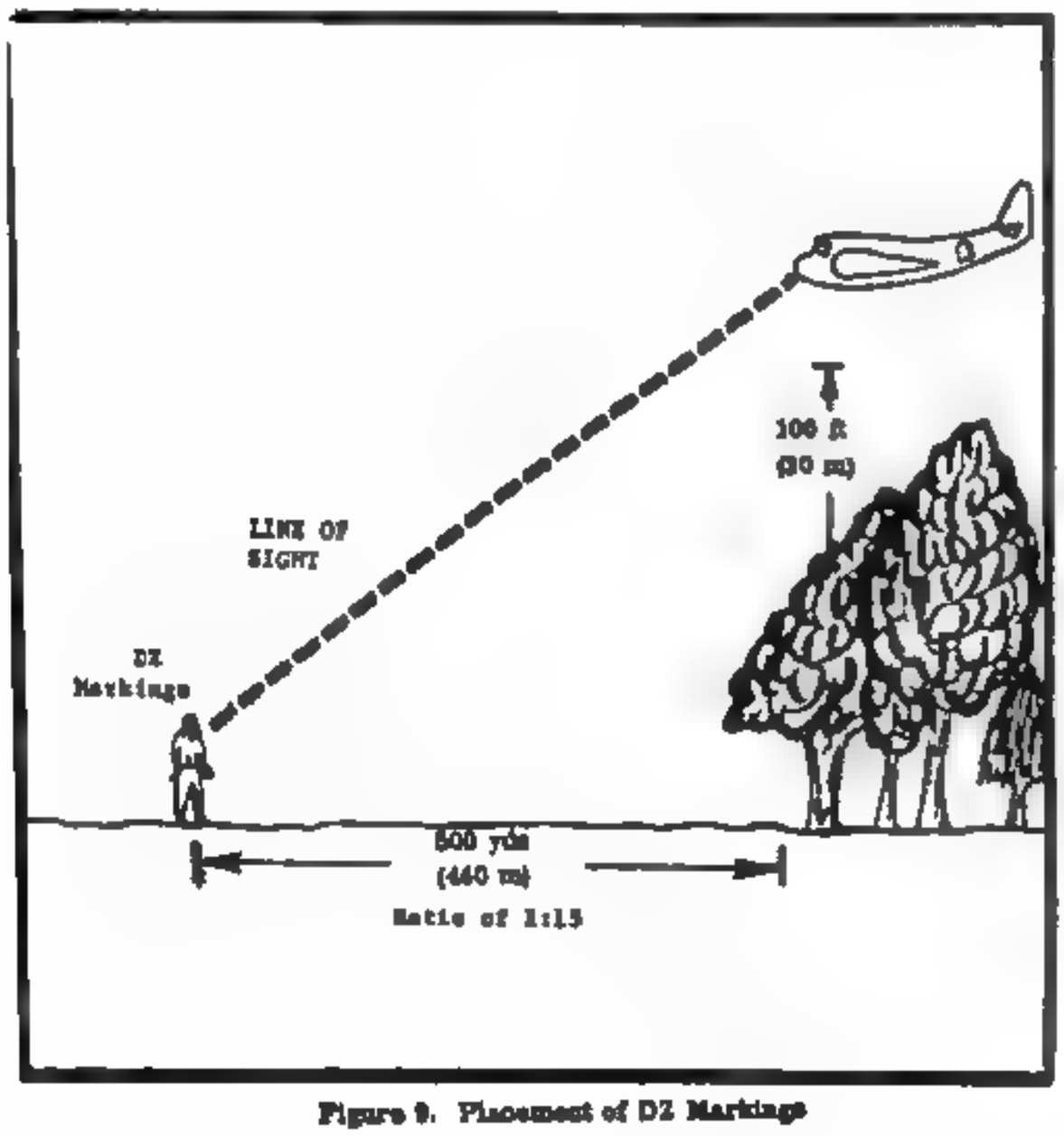


Figure 9. Placement of DZ Markings

a. Placement of Markings.

1. Markings must be clearly visible to the pilot of the approaching aircraft. As a guide, markings must have a clearance of at least 500 yards (460 meters) from a 100-foot (30 meter) mark (Figure 9).

2. Additionally, precautions must be taken to insure that the markings can be seen only from the direction of the aircraft approach. Flashlights may be equipped with simple hoods or shields and aimed toward the flight path. Fires or improvised flares are screened on three sides or placed in pits with sides sloping toward the direction of aircraft approach.

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3. When panels are used for daylight markings of DZ's, they are positioned at an angle of approximately 45° from the horizontal to present the maximum surface toward the approaching aircraft (Figure 10).

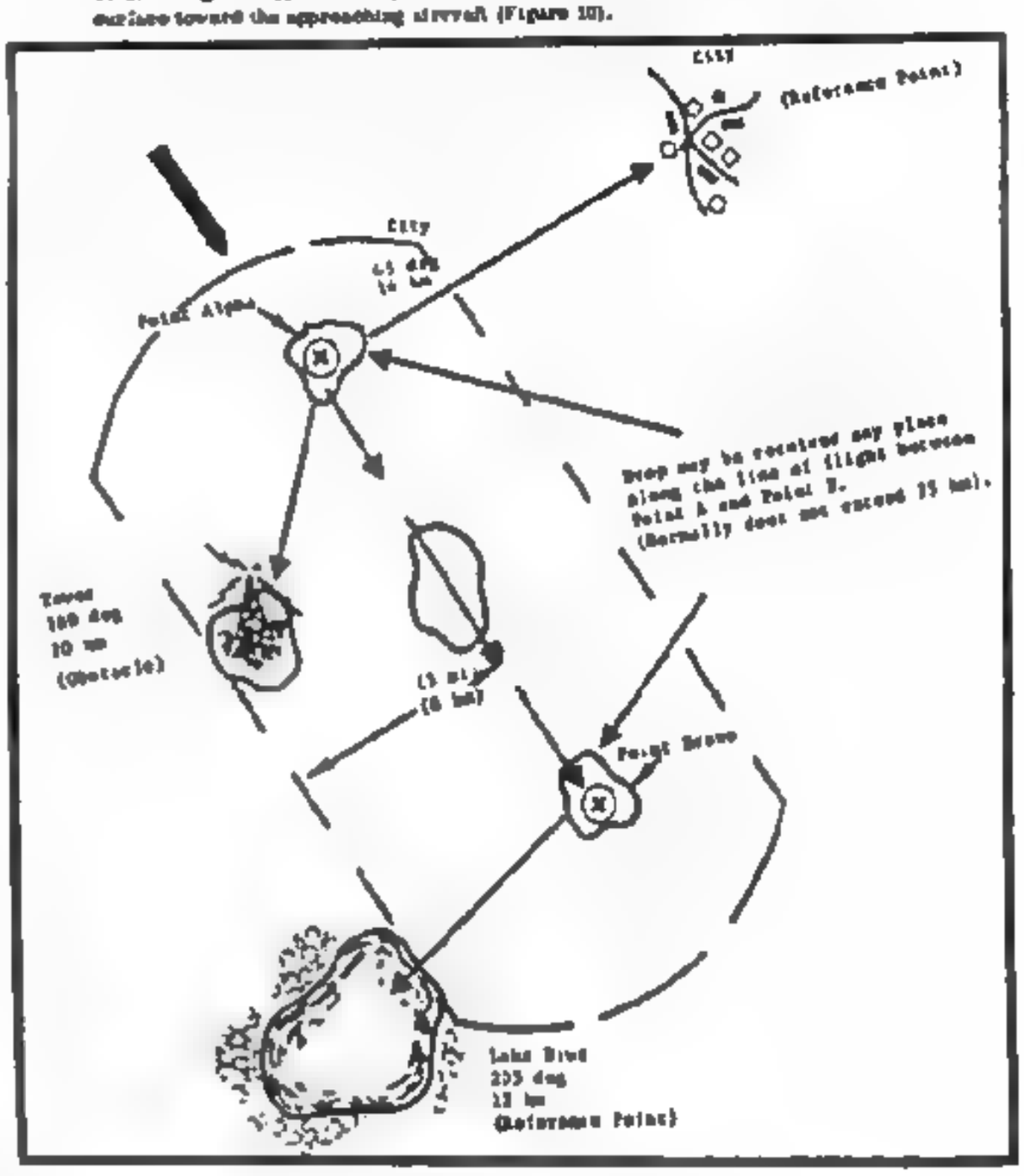

Figure 10. Obstacles and Reference Point (Area DZ)

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V. RECEPTION COMMITTEES:

a. General. A reception committee is formed to control the drop zone or landing area. The reception committee can be anyone who is capable of performing the following duties. A permanent committee for each unit provides the best results, eliminating the need to cross train every one to be capable of this mission. However, training in depth should be accomplished to insure that losses of key personnel will not adversely affect the operation of the group as a whole.

(1) Provide security for the reception operation.

(2) Emplace DZ markings and air ground identification equipment.

(3) Maintain surveillance of the site prior to and following the reception operation.

(4) Recover and dispose of incoming personnel and/or cargo.

(5) Provide for dispatch of personnel and/or cargo in evacuation opera-

(6) Provide for sterilization of the site (when secrecy is possible and desirable only).

c. Composition. The reception committee is normally organized into five

parties. The composition and functions of the five parties are as follows:

(1) Command party.

(a) Controls and coordinates the actions of all reception committee components.

(b) Includes the reception committee leader (RCL) and communications personnel, consisting of messengers and radio operators.

(c) Provides medical support, to include litter bearers, during personnel drops.

(2) Marking party.

(a) Operates the reception site marking system, using one man for each marker.

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(b) The marking party must be well rehearsed. Improperly placed or improperly operated markings may cause an aborting of the mission.

(3) Security party.

(a) Insures that unfriendly elements do not interfere with the conduct of the operation.

(b) Consists normally of inner and outer security elements.

1. The inner security element is positioned in the immediate vicinity of the site and is prepared to fight delaying or holding actions.

2. The outer security element consists of outposts established along approaches to the area. They may prepare ambushes and road blocks to prevent enemy movement toward the site.

(c) The security party may be supplemented by auxiliaries. These are generally used to maintain surveillance of enemy activities and keep the security party informed of hostile movements.

(d) Provides march security for moves between the reception site and the destination of the cargo or infiltrated personnel.

(4) Recovery party.

(a) Recovers cargo and aerial delivery equipment from the DZ. Unloads aircraft or landing craft.

(b) For aerial delivery operations the recovery party should consist of at least one man for each parachutist or cargo container. For such operations, the recovery party is usually dispersed along the length of the anticipated impact area. The members spot each parachute as it descends and move to the landing point. They then recover all parachute equipment and cargo, moving to a predetermined assembly area with the infiltrated personnel or equipment.

(c) The recovery party is normally responsible for sterilizing the reception site to insure that all traces of the operation are removed when secrecy is possible and desired.

(5) Transport party.

(a) Moves items received to distribution points or caches.

(b) May consist of part, or all, of the members comprising the command, marking, and recovery parties.

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VI. LANDING ZONES (LAND)

a. General. The same general considerations applicable to DZ selections apply to the selection of LZ's. However, site size, approach features and security are far more important.

b. Selection Criteria.

(1) Desirable terrain features:

(a) LZ's should be located in flat or rolling terrain.

(b) Level plateaus of sufficient size can be used. Due to decreased air density, landings at higher elevations require increased minimum LZ dimensions

(c) Uses available means of transportation such as pack animals and wagons.

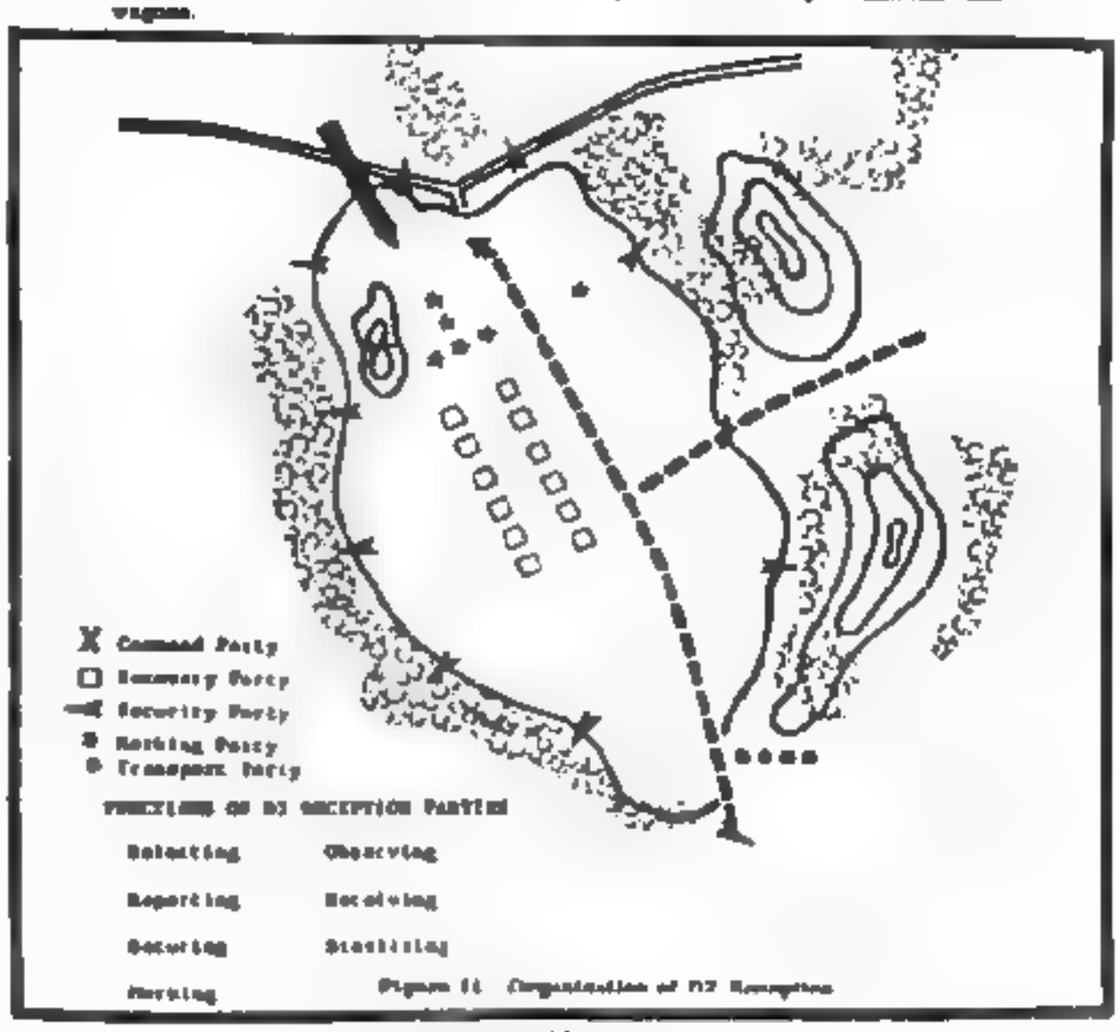

Figure 11. Organization of DZ Reception Parties

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If the LZ is located in terrain above 4,000 feet (1,220 meters) and/or areas with a very high temperature the minimum lengths should be increased as follows:

1. Add 10 percent to minimums for each 1,000 feet (305 meters).

2. Add 10 percent to minimum for the altitude for temperatures over 90°F. Add 20 percent for temperatures over 100°F (38°C).

(e) Pockets or small valleys completely surrounded by hills are usually unsuitable for landing operations by fixed-wing aircraft.

(f) Although undesirable, sites with only a single approach can be used. It is mandatory when using such sites that:

1. All takeoffs and landings are made upwind.

2. There is sufficient clearance at either end of the LZ to permit a level 180° turn to either side within a radius of 2 miles (3 kilometers) for medium aircraft (1 mile for light aircraft).

IV-21

(2) Weather. Prevailing weather in the landing area should be favorable. In particular, there must be a determination of wind direction and velocity, and of conditions restricting visibility such as ground fog, haze, or low-hanging cloud formations.

(3) Size. The required size of LZ's varies according to the aircraft used. Safe operations require the following minimum dimensions (Figures 12 and 13).

(a) Medium aircraft. 3,000 feet (920 meters) in length and 100 feet (30 meters) in width (150 feet or 45 meters at night).

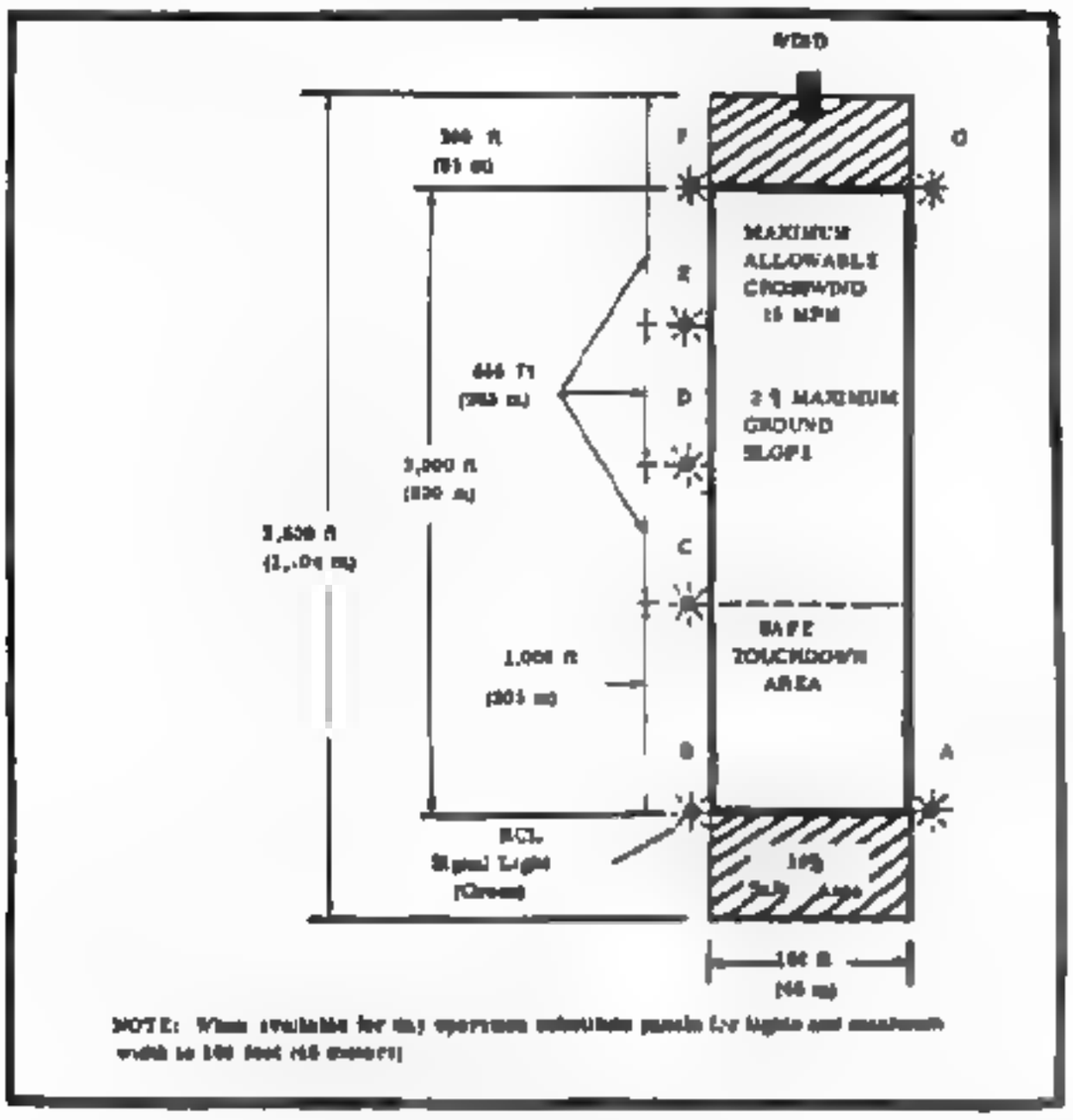
(b) Light aircraft. 1,000 feet (305 meters) in length and 40 feet (15 meters) in width (150 feet or 45 meters at night).

(c) In addition to the basic runway dimensions, and to provide a safety factor, these extra clearances are required.

1. A cleared surface capable of supporting the aircraft, extending from each end of the runway, and equal to 10 percent of the runway length.

2. A 50-foot (15 meter) strip extending along both sides of the runway and cleared to within three feet of the ground.

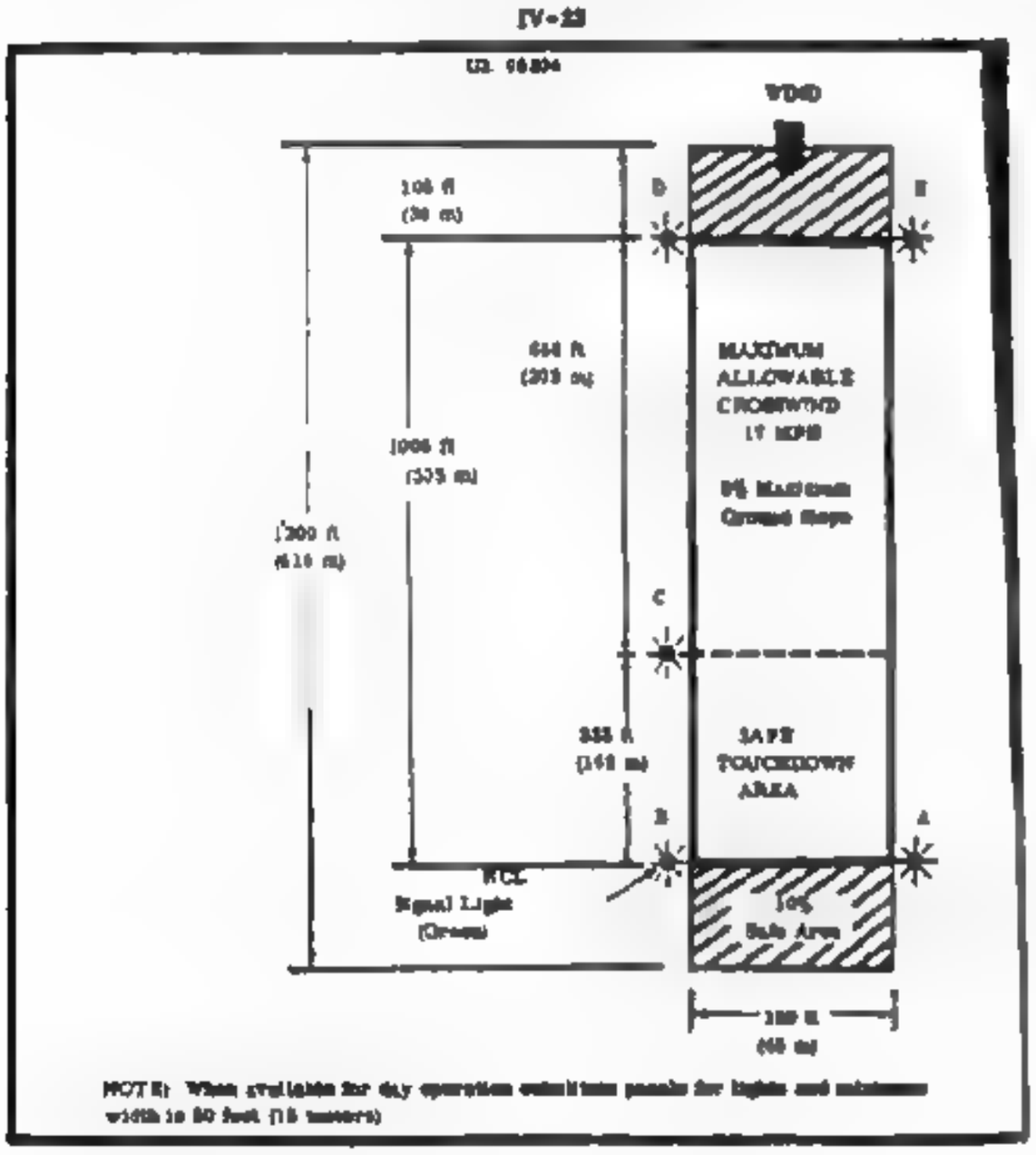
IV-22



NOTE: When available for day operations substitute panels for lights and maximum width is 100 feet (45 meters)

Figure 13. Landing zone (land) medium aircraft (night operations).

IV-23



NOTE: When available for day operations substitute panels for lights and maximum width is 80 feet (24 meters)

Figure 13. Landing zone (land) light aircraft (night operations).

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(4) Surface.

(a) The surface of the LZ must be level and free of obstructions such as ditches, deep ruts, logs, fences, hedges, low shrubbery, rocks larger than a man's fist or grass over 1 1/2 feet in height.

(b) The sub-soil must be firm to a depth of 2 feet.

(c) A surface-containing gravel and small stones, or thin layers of loose sand over a firm layer of sub-soil is acceptable. Plowed fields or fields containing crops over 1 1/2 feet in height should not be used.

(d) As with DZ's surfaces that are not desirable in summer may be ideal in winter. Ice with a thickness of 2 feet (61 centimeters) will support a medium aircraft. Unless the aircraft is equipped for snow landing, snow in excess of 4 inches (11 centimeters) must be packed or removed from the landing strip.

(e) The surface gradient of the LZ should not exceed 3 percent.

(5) Approach and takeoff clearance. The approach and takeoff clearances are based on the glide-climb characteristics of the aircraft. For medium aircraft the glide-climb ration is 1 to 40; that is, 1 foot of gain or loss of altitude for every 40 feet of horizontal distance traveled. The ration for light aircraft is 1 to 20. As a further precaution, any obstructions in approach and departure lanes must conform to the following specifications (Figure 14).

(a) An obstruction higher than 6 feet (2 meters) is not permissible at or near either end of the L.Z.

(b) A 50-foot (15 meters) obstruction may not be nearer than 2,000 feet (610 meters) for medium aircraft, or 1,000 feet (305 meters) for light aircraft.

(c) A 500-foot (155 meter) obstruction may not be nearer than 4 miles (617 kilometers) for medium aircraft or 2 miles (305 meters) for light aircraft.

(d) Hills of 1,000 (305 meters) feet or more above LZ altitude may not be nearer than 8 miles (13 kilometers) from the landing zone for medium aircraft.

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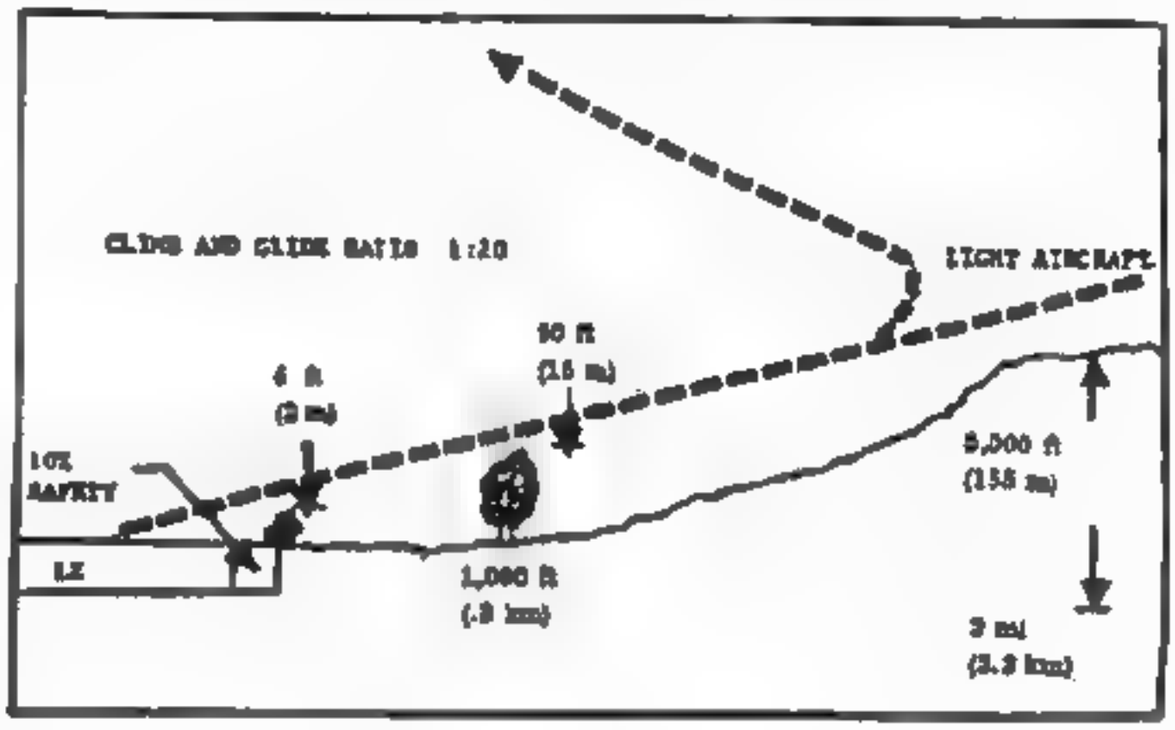

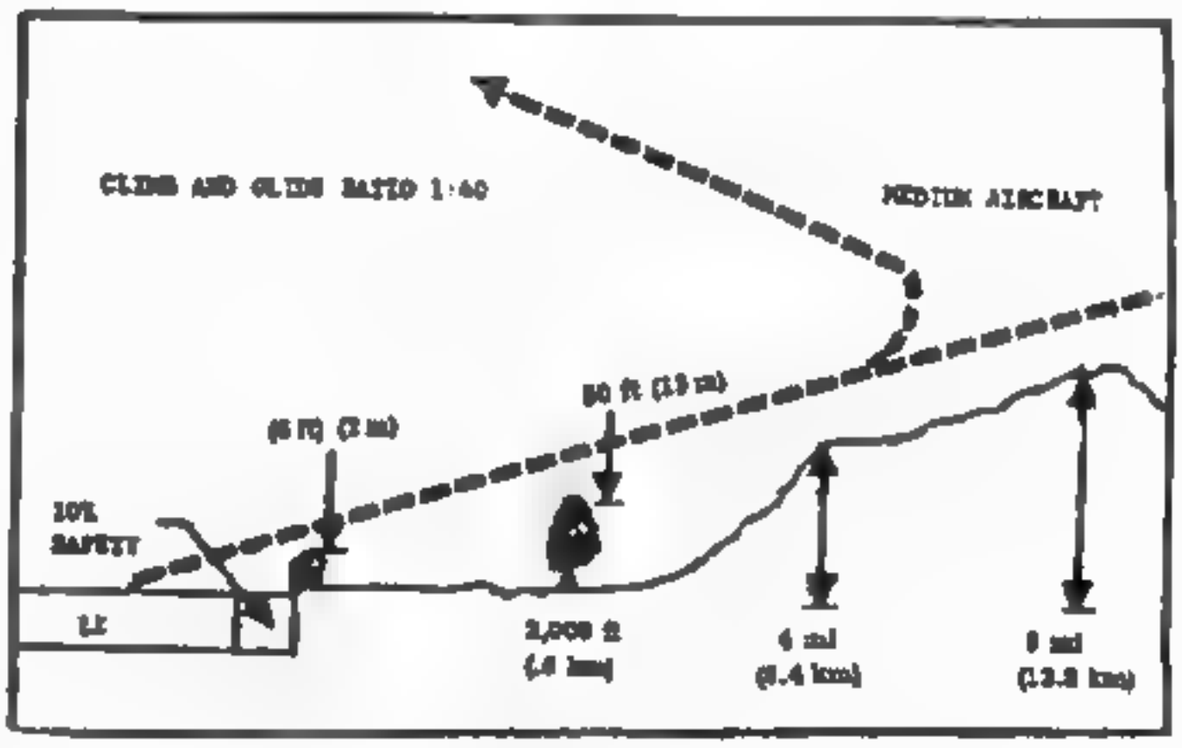

Figure 14

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(6) The heights of the obstacles are computed from the level of the landing strip. Where land falls away from the LZ, objects of considerable height may be ignored provided they do not cut the line of ascent or descent. This condition exists more often in mountainous terrain where plateaus are selected for LZ's

c. Markings.

(1) For night operations lights are used for marking LZ's; during daylight, panels are used. When flashlights are used, they should be hand-held for directional control and guidance.

(2) The pattern outlining the limits of the runway consists of five or seven marker stations (Figures 11 and 12). Stations "A" and "B" mark the downwind end of the LZ and are positioned to provide for the safety factors previously mentioned. These stations represent the initial point at which the aircraft should touch the ground. Station "C" indicates the very last point at which the aircraft can touch down and complete a safe landing.

(3) A signal station manned by the RCL (a member of the operational detachment) is incorporated into light station "B" at the approach or downwind end of the LZ (Figures 11 and 12). For night operations, (the signal light operations) a distinctive panel or colored smoke, located approximately 15 meters to the left of station "B" (RCL), is used for recognition.

[redacted]

(1) The LZ markings are normally displayed 2 minutes before the arrival time indicated in the mission confirmation message. The markings remain displayed for a period of 4 minutes or until the aircraft completes landing roll after [redacted]

(2) Identification is accomplished by:

(a) The aircraft arriving at the proper time on prearranged track.

(b) The reception committee leader flashing or displaying the proper code signal.

(3) Landing direction is indicated by:

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(a) The RCL signal control light (station "B") and marker "A" which are always on the approach or downwind end of the runway.

(b) The row of markers which are always on the left side of the landing aircraft.

(4) The pilot usually attempts to land straight-in on the initial approach. When this is not possible, a modified landing pattern is flown using a minimum of altitude for security reasons. Two minutes before target time the RCL causes all lights of the LZ pattern to be turned on and aimed like a pistol in the direction of the aircraft's approach track. The RCL (station "B") also flashes the code of the day continuously with the green control light in the direction of expected aircraft approach. Upon arrival in the area (within 15° to either side of the approach track and below 1,500 feet (460 meters), the LZ marking personnel follow the aircraft with all lights when it arrives in the area. When the RCL determines that the aircraft is on its final approach, he will cease flashing the code of the day and aim a solid light in the direction of the landing aircraft. The solid light provides a more positive pattern perspective for the pilot during landing. If a "go around" is required, all lights follow the aircraft until it is on the ground. All lights continue to follow the aircraft during touchdown and until it passes each respective light station.

(5) Landings are not normally made under the following conditions:

(a) Lack of or improper identification received from the LZ.

(b) An abort signal given by the RCL, e.g., causing the LZ lights to be extinguished.

(c) Any existing condition that, in the opinion of the pilot, makes it unsafe to land.

(6) After the aircraft passes the RCL position at touchdown and completes its landing roll and a right turn, the RCL takes a position midway between stations "A" and "B" and shines a solid light in the direction of the taxiing aircraft. This is the guide light for the pilot who will taxi the aircraft back to takeoff position. The RCL controls the aircraft with his light. If the RCL desires the aircraft to continue to taxi, he will flash a solid light in the direction of the aircraft. After off-loading and/or on-loading is complete and the aircraft is ready for takeoff, the RCL moves to a vantage point forward and to the left of the

IV-28

pilot, causes the LZ lights to be illuminated, and flashes his light toward the nose of the aircraft as the signal for takeoff. The RCL exercises caution so that his light does not blind the pilot.

(7) To eliminate confusion and insure expeditious handling, personnel and/or cargo to be evacuated wait for unloading of incoming personnel and/or cargo.

(8) When all evacuating personnel are loaded and members of the reception committee are clear of the aircraft, the pilot is given a go signal by the RCL. LZ markings are removed as soon as the aircraft is airborne.

VII. REPORTING LANDING ZONES

The minimum LZ data required is:

a. Code Name. Extracted from SOI.

b. Location. Complete military grid coordinates of center of LZ.

c. Long Axis. Magnetic azimuth of long axis of runway. It also indicates probable direction of landing approach based on prevailing winds.

d. Description. Type of surface, length, and width of runway.

e. Open Quadrant. Measured from center of LZ and reported as series of magnetic azimuths. Open Quadrant indicates acceptable aircraft approaches.

f. Track. Magnetic azimuth of desired aircraft approach.

g. Obstacles. Reported by description, magnetic azimuth, and distance from center of LZ.

h. Reference Point. Reported same as obstacles.

i. Date. Time mission requested.

j. Items Requested. Items to be evacuated.

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VIII. LANDING ZONES FOR ROTARY-WING AIRCRAFT:

a. General.

(1) Within their range limitations, helicopters provide an excellent means of evacuation. Their advantages include the ability to:

(a) Ascend and descend almost vertically.

(b) Land on relatively small plots of ground.

(c) Hover nearly motionless, and take on or discharge personnel and cargo without landing.

(d) Fly safely and efficiently at low altitudes.

(2) Some unfavorable characteristics of helicopters are:

(a) They compromise secrecy by engine and rotor noise and by dust.

(b) The difficulty--sometimes impossibility--of operating when icing and/or high, gusty winds prevail.

(c) The reduction of lifting ability during changes of atmospheric conditions.

(3) For the maximum effective use of helicopters, LZ's should be located to have landings and takeoffs into the wind.

(4) During night operations, helicopters usually must land to transfer personnel and/or cargo.

(5) A decrease in normal air density limits the helicopter payload and requires lengthened running distances for landing and takeoff. Air density is largely determined by altitude and temperature. Low altitudes and moderate to low temperatures result in increased air density.

b. Size. Under ideal conditions, and provided the necessary clearance for the

IV-30

rotors exists, a helicopter can land on a plot of ground slightly larger than the spread of its landing gear. For night operations, however, a safety factor is allowed with the following criteria as a guide:

(1) An area of 50 meters in diameter cleared to the ground.

(2) An area beyond this, surrounding the cleared area, 20 meters wide and cleared to within 3 feet of the ground.

(3) The completed LZ is thus a minimum of 90 meters in diameter (Figure 16).

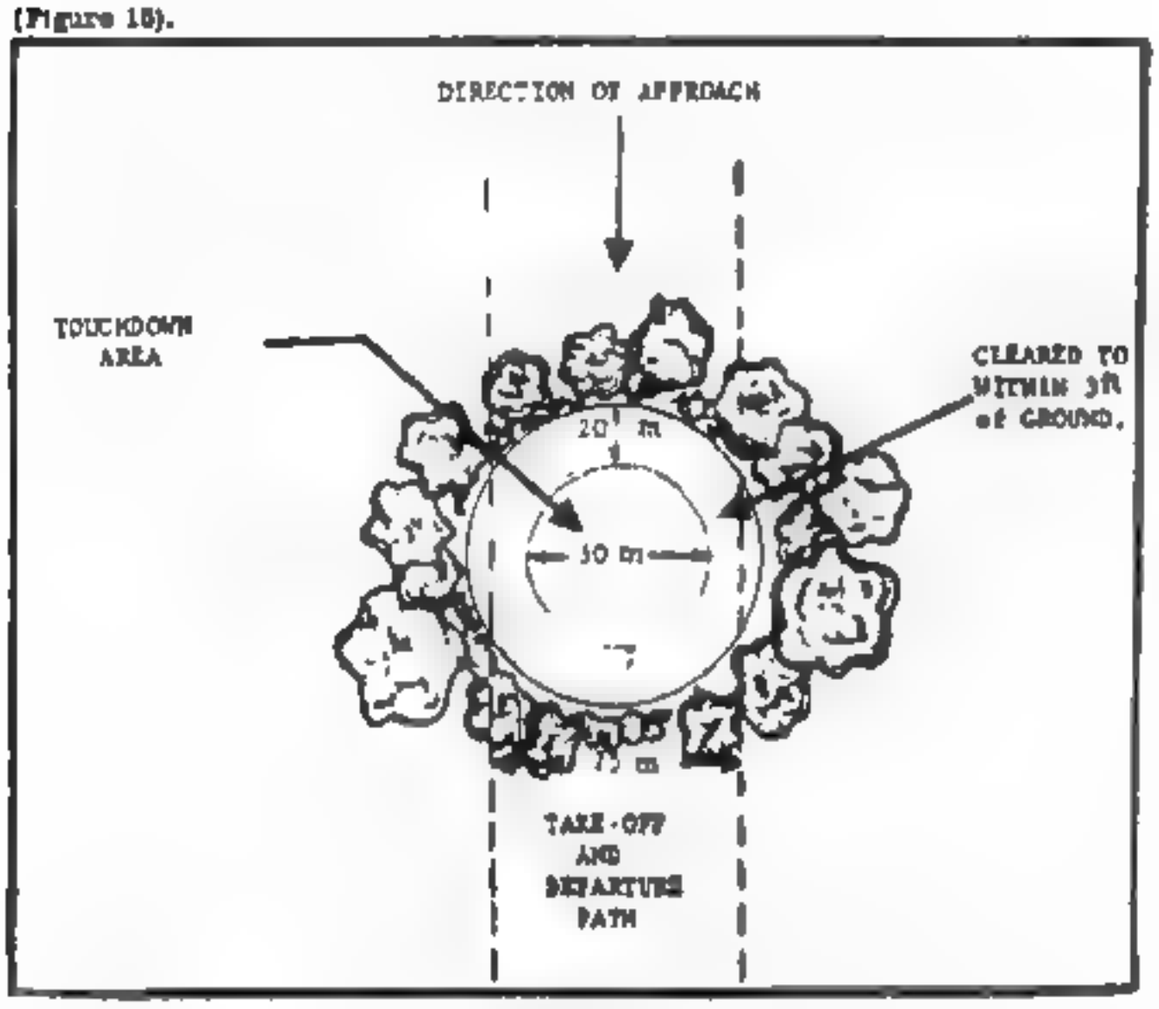

Figure 16. Landing Zone for Rotary-Wing Aircraft.

a. Surface.

(1) The surface should be relatively level and free of obstructions such as rocks, logs, tall grass, ditches, and fences.

(2) The maximum ground slope permitted is 15 percent.

(3) The ground must be firm enough to support the aircraft.

(4) Heavy dust or loose snow conditions interfere with the vision of the pilot just before touchdown. This effect can be reduced by clearing, wetting down, or using improvised mats.

(5) Landing pads may be prepared on swamp or marsh areas by building platforms of locally available materials (Figure 18). Such LZ's are normally used for daylight operations only. The size of the clearing for this type of LZ is the same as 1 above, with the following additional requirements for the platform:

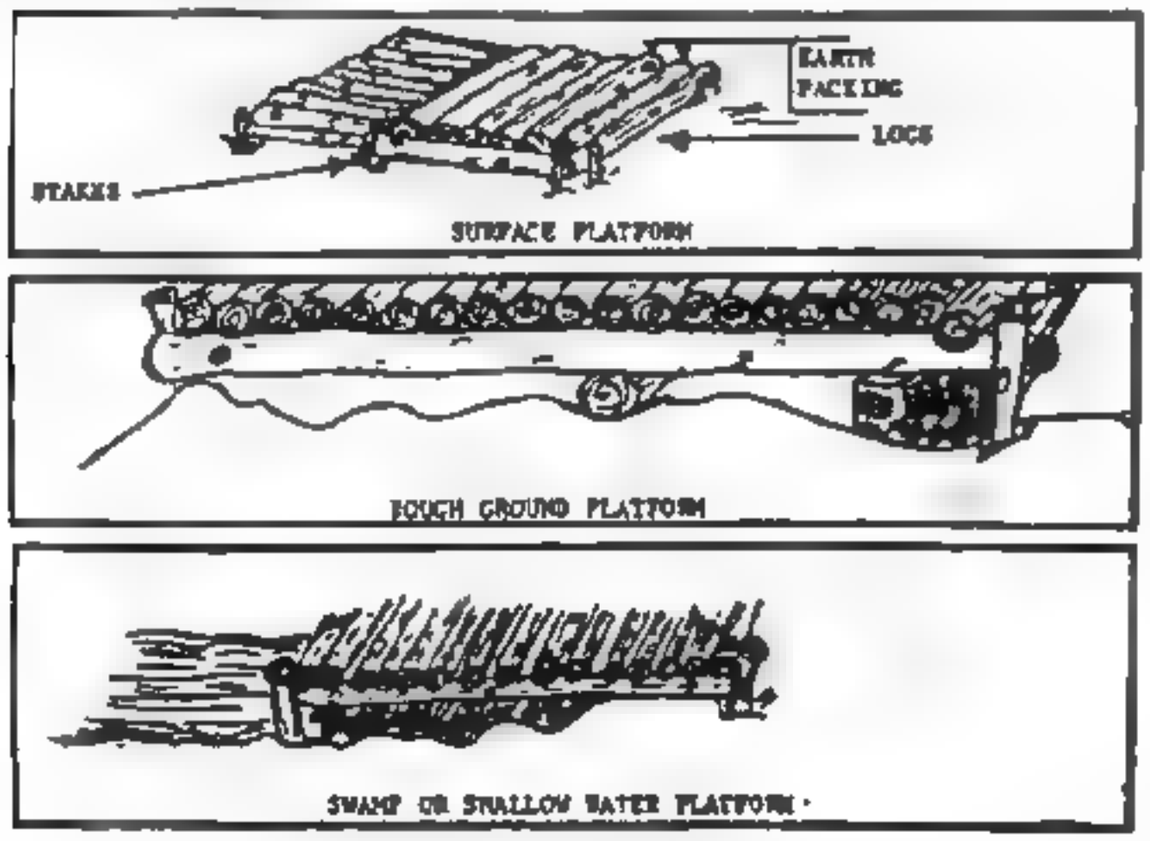

Figure 18. Examples of platform landing zones for rotary-wing aircraft.

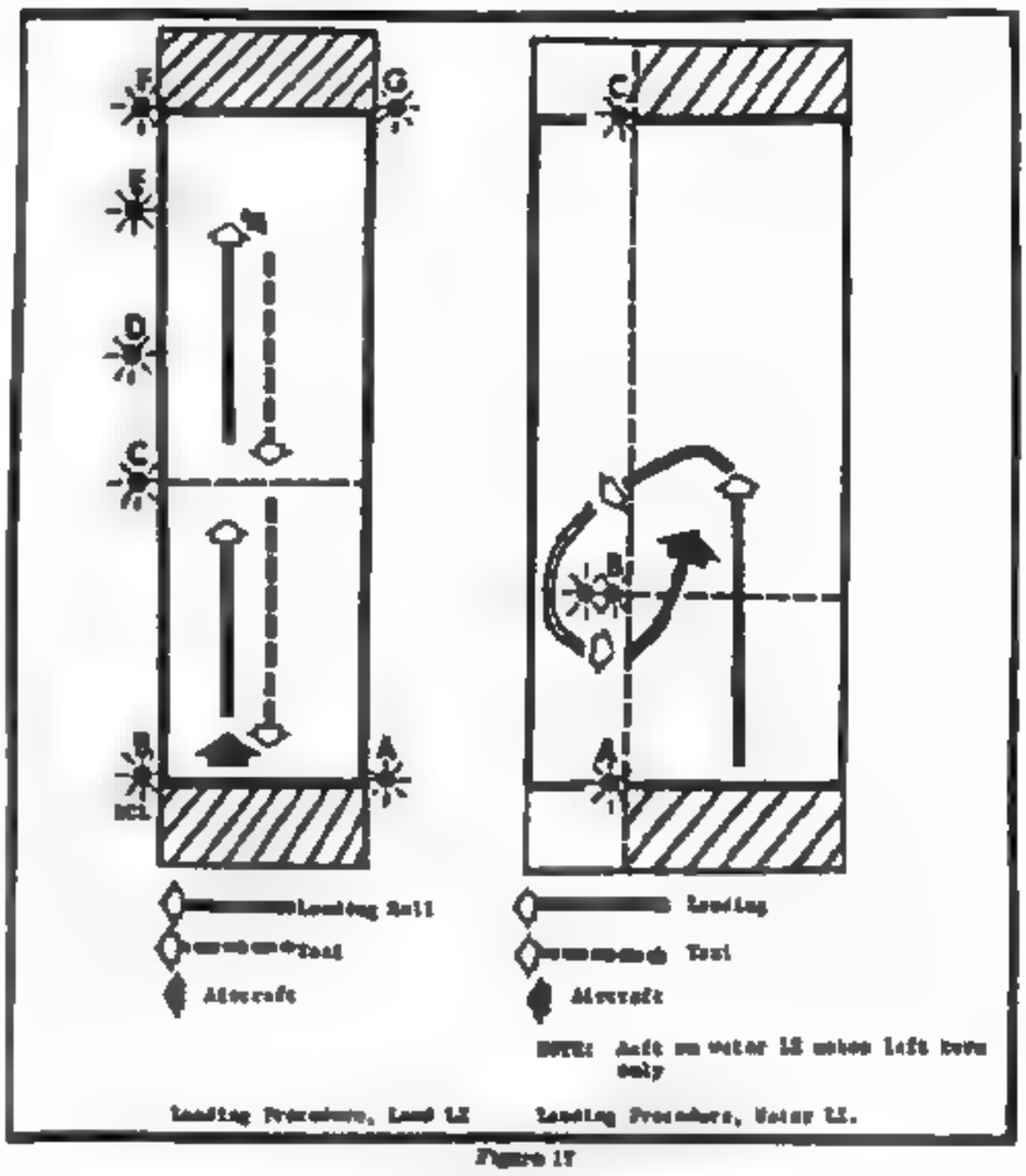

Figure 17

IX. LANDING ZONES (WATER)

a. Criteria for selection of water LZ's)

(1) Size. For medium amphibious or seaplane-type aircraft, the required length is 6,600 feet (1,320 meters) with a minimum width of 1,100 feet (440 meters). For light aircraft, the required length is 3,000 feet (915 meters) long and 300 feet (135 meters) wide. As with land LZ's, and additional safe area equal to 10 percent of the airstrip length is required on each end. (Figure 19)

(2) Surface. Minimum water depth is 6 feet (2 meters). The entire landing zone must be free of obstructions such as boulders, rock ledges, shoals, waterlogged boats, or sunken pilings within 6 feet of the surface, and the surface must be cleared of all floating objects such as logs, debris, or moored craft.

(3) Wind.

(a) Wind velocity must not exceed 20 knots for sheltered water or 10 knots in semi-sheltered water.

(b) In a wind of 8 knots or less, the landing heading may vary up to 15 degrees from the wind direction. Where the surface winds exceed 8 knots the aircraft must land into the wind. No landing may be made in winds in excess of 20 knots. If a downwind landing or takeoff is absolutely required, this is made directly downwind.

(c) Surface swells must not exceed 1 foot in height and the windwave not more than 3 feet. The combination of swell and windwave must not exceed 3 feet in height when all swells and windwaves are in phase.

(4) Tide. The state of the tide should have no bearing on the suitability of the landing area.

(5) Water/air temperature. Due to the danger of icing, water and air temperatures must conform to the following minimums:

	Water temperature	Air temperature
Salt water	- 15°F. (-8°C.)	- 25°F. (-1°C.)
Fresh water	- 35°F. (-2°C.)	- 28°F. (-2°C.)
Brackish water	- 30°F. (-1°C.)	- 28°F. (-2°C.)

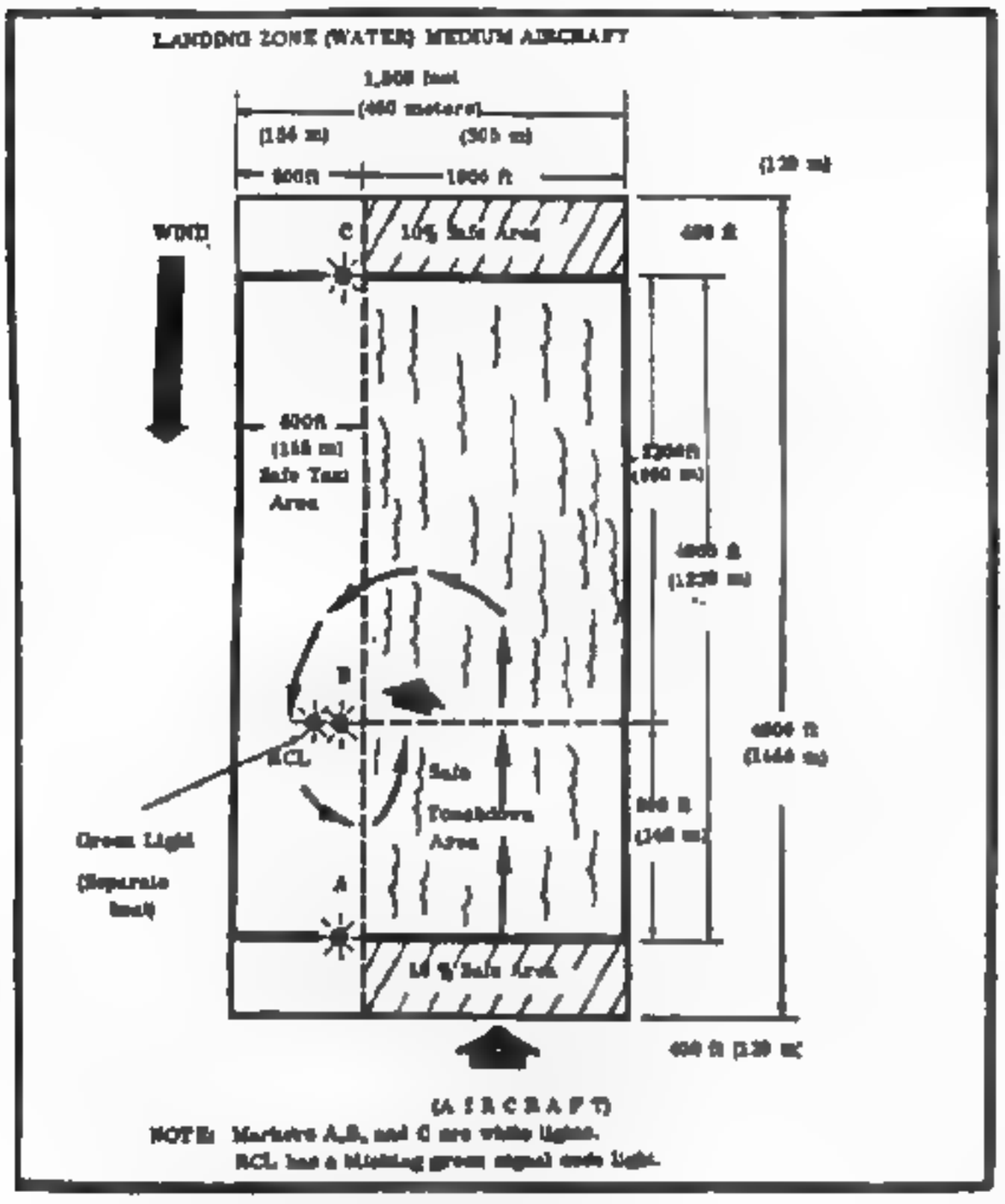

Figure 11. Landing Zone (water) medium aircraft (night operations).

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(6) Approach and takeoff clearances. Water landing zones require approach/takeoff clearances identical to those of land LZ's and are based on the same glide/climb ratios.

c. Marking and identification of water landing zones.

(1) Depending upon visibility, lights or panels may be used to mark water LZ's.

(2) The normal method of marking water LZ's is to align three marker stations along the left edge of the landing strip. Station "A" is positioned at the downwind end of the strip and indicates the desired touchdown point. Station "B" marks the last point at which the aircraft can touch down and complete a safe landing. Station "B" is also the location of the RCL and the pickup point. Station "C" marks the upwind extreme of the landing area. At night, stations "A," "B," and "C" are marked by white lights. The RCL signal light is green.

(3) An alternate method is to use a single marker station, marked at night with a steady light in addition to the signal of recognition light. This station is located to allow a clear approach and takeoff in any direction. The pilot is responsible for selecting the landing track and may touchdown on any track 1,000 feet (305 meters) from the marker station. Following pickup, the aircraft taxis back to the 2,000-foot (610 meters) circle in preparation for takeoff. (Figure 10).

d. Conduct of operations for water LZ's.

(1) Before the landing operation, the LZ is carefully cleared of all floating debris. Also, the marker stations are properly aligned and anchored to prevent drifting. In deep or rough water, improvised sea anchors may be used.

(2) The procedure for displaying the LZ markings and identification is the same as for operations on land LZ's.

(3) Personnel and/or cargo to be evacuated are positioned in the RCL boat. Following the landing run, the aircraft turns to the left and taxis back to the vicinity of the RCL boat to make the pickup. The RCL indicates his position by shining the signal light in the direction of the aircraft and continues to shine his light until the pickup is completed. Care must be taken not to blind the aircrew with this light and it should not be aimed directly into the cockpit.

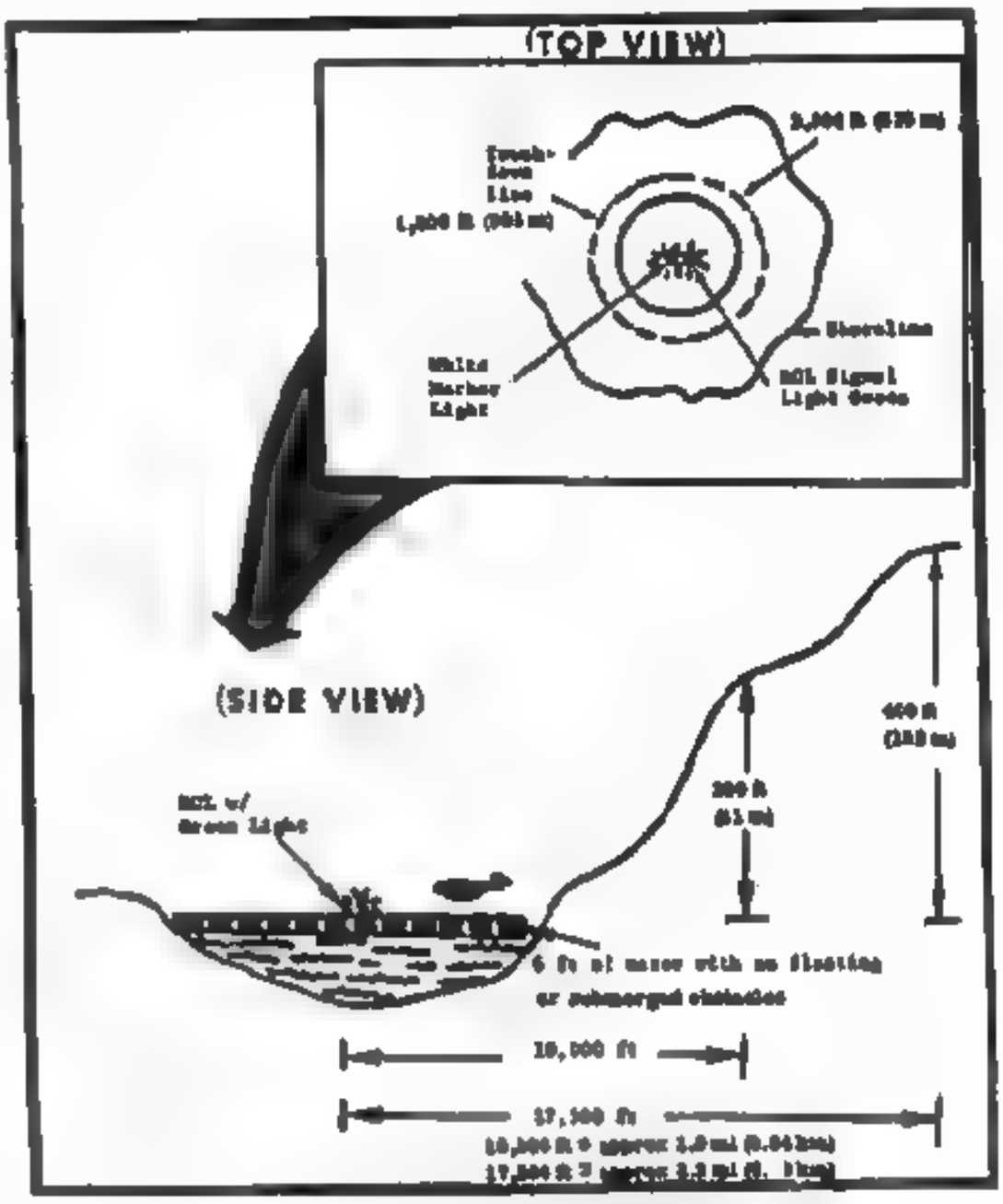

Figure 10. One light water landing zone (night).

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(4) The RCL boat remains stationary during pickup operations. The aircraft taxis to within 50 to 100 feet (15 or 30 meters) of the RCL boat, playing out a dragline from the left rear door. The dragline is approximately 150 feet (46 meters) in length and has three life jackets attached; one close to the aircraft, a second at midpoint, and the third on the extreme end of the line. The life jackets have small marker lights attached during night operations. The aircraft taxis to the left around the RCL boat, bringing the dragline close enough to be secured. The RCL fastens the line to the boat. Due to the danger of swamping the craft, the RCL does not attempt to pull on the line. Members of the aircrew pull the boat to the door of the aircraft. Should the boat pass the aircraft door and continue toward the front of the aircraft, all personnel in the boat must abandon immediately to avoid being hit by the propeller.

(5) After pickup, the aircrew is given any information that will aid in the takeoff. Following this, the RCL boat moves a safe distance from the aircraft and signals the pilot "all clear." At this time, JATO bottles may be used for positive takeoff power. The installation of JATO bottles is time consuming and should not be done unless absolutely necessary.

(6) Helicopters can land in water without the use of special flotation equipment provided:

(a) The water depth does not exceed 18 inches.

(b) There is a firm bottom such as gravel or sand.

(7) Landing pads can be prepared on mountains or hillsides by cutting and filling. Caution must be exercised to insure there is adequate clearance for the rotors.

e. Approach/Takeoff.

(1) There should be at least one path of approach to the LZ measuring 75 [illegible] in width.

(2) A rotary wing aircraft is considered to have a climb ratio of 1:6 (Figure 30).

(3) Takeoff and departure from the LZ may be along the same path used for the approach; however, a separate departure path as free from obstacles as the approach path is desired (Figure 30).

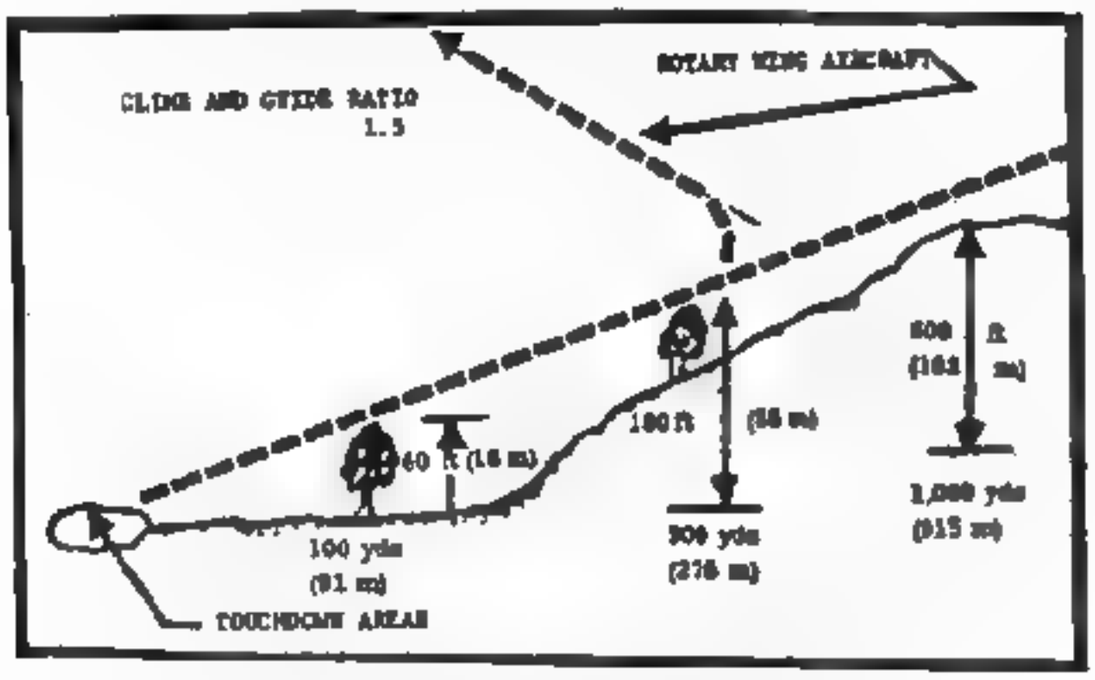

Figure 20. Approaching Takeoff Clearances for Rotary-Wing Aircraft.

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4. Marking.

(1) LZ's for rotary-wing aircraft are marked to:

(a) Provide identification of the reception committee.

(b) Indicate direction of wind and/or required direction of approach.

(c) Delineate the touchdown area.

(2) Equipment and techniques of marking are similar to those used with fixed-wing DZ s, lights or flares at night, smoke and panels in daylight.

(3) An acceptable method of marking is the "T" system. This uses four marker stations (Figure 21).

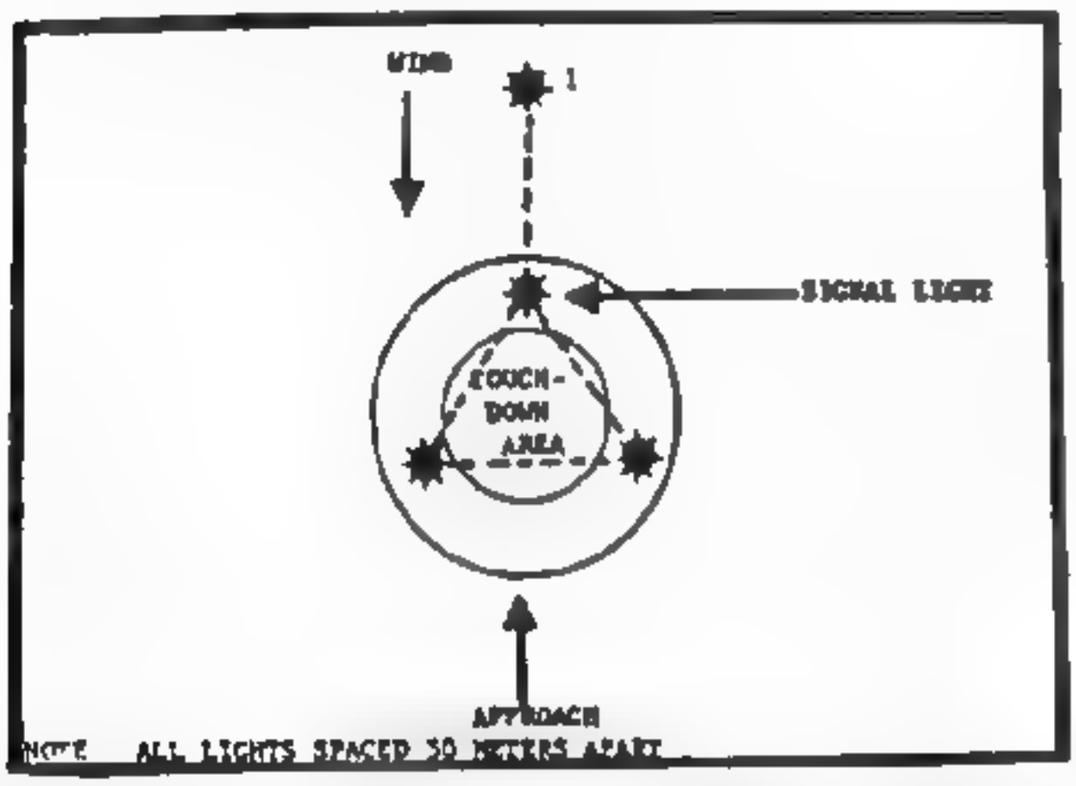

Figure 21. Marking of landing zones for use by rotary-wing aircraft.

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TABLE NR. 1. FIXED AND ROTARY WING AIRCRAFT CAPABILITIES

Air Craft	Cruise Speed (Knots)	Range Full Fuel NM	Payload 60 NM Radius	Payload 100 NM Radius	Type Cabin Equipped	Litters	Cu. Ft. Cargo Space	External Sling Capacity
UH-1B	90	110	1090	1600	7	3	140	3000
UH-1D	100	350	3300	2700	11	6	220	4000
CH-21	80	240	4000	2600	20	12	422	8000
CH-34	80	200	4000	2500	15	6	363	4000
CH-37	80	130	6800	4100	25	24	1143	10000
H--	87	250	800	800	2	--	--	--
U-6	106	575	1300	1150	4	2	125	--
U-8F	150	1100	1300	2100	4	4	191	--
U-1A	100	700	1400	1200	0	6	224	--
CV-1	200	410	2000	--	--	--	--	--
CV-2	237	1300	7800	7800	32	14	1140	--

NOTE: Above figures are to be used as guides only. Many factors will influence the capabilities of any aircraft. Increases in temperature, humidity and altitude will decrease performance. Desired range will affect fuel load which will determine number of troops or amount of cargo that can be carried.

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CHAPTER 5

WEAPONS

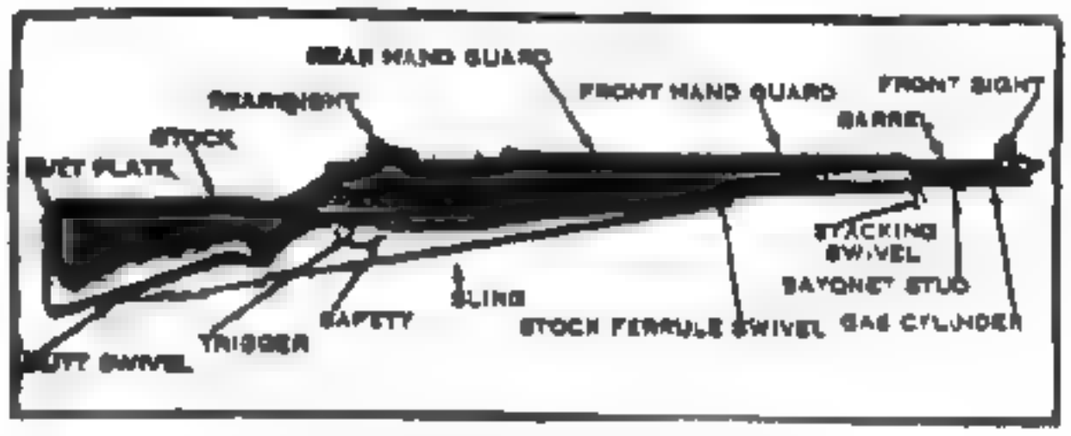


Figure 1 U.S. Rifle Caliber .30 M-1

1. Characteristics:

a. Aircooled
b. Semi-automatic
c. Gas operated
d. Shoulder weapon
e. Clip loaded

2. Data:

a. Maximum effective range (500 yds)
b. Maximum range (3,450 yds)
c. Clip capacity (8 rds)

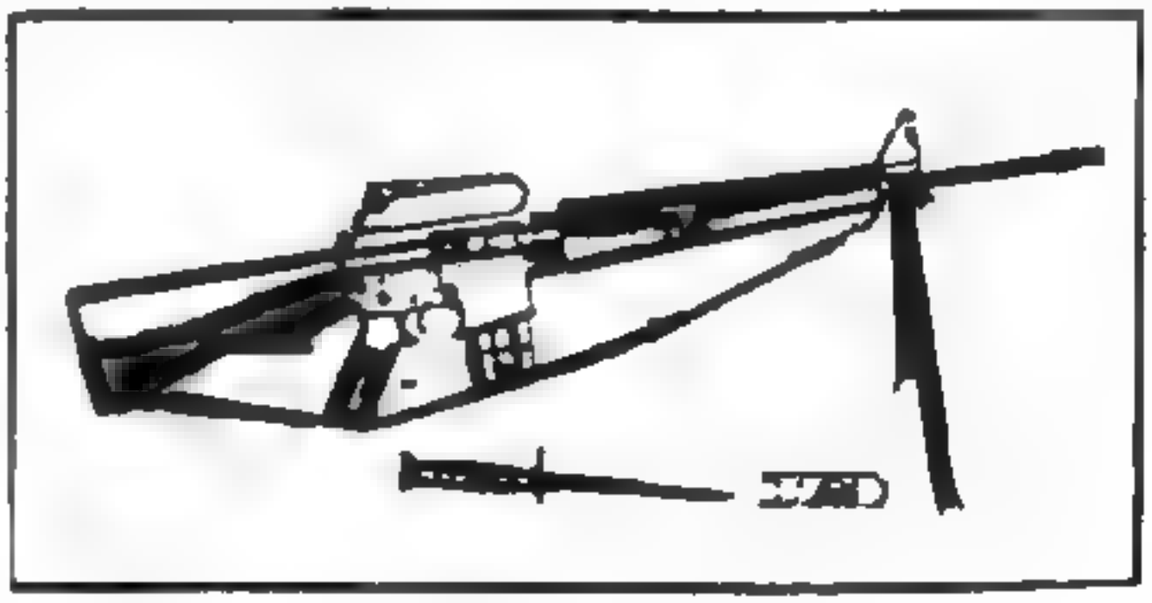


Figure 2 Colt AR-15, Cal .223
(Redesignated M-16 Rifle)

1. Characteristics:

a. Gas operated
b. Air cooled
c. Semi of fully automatic
d. Shoulder weapon
e. Magazine fed

2. Data:

a. Maximum range (2533 yds)
b. Maximum effective range (500 yds)

V-1

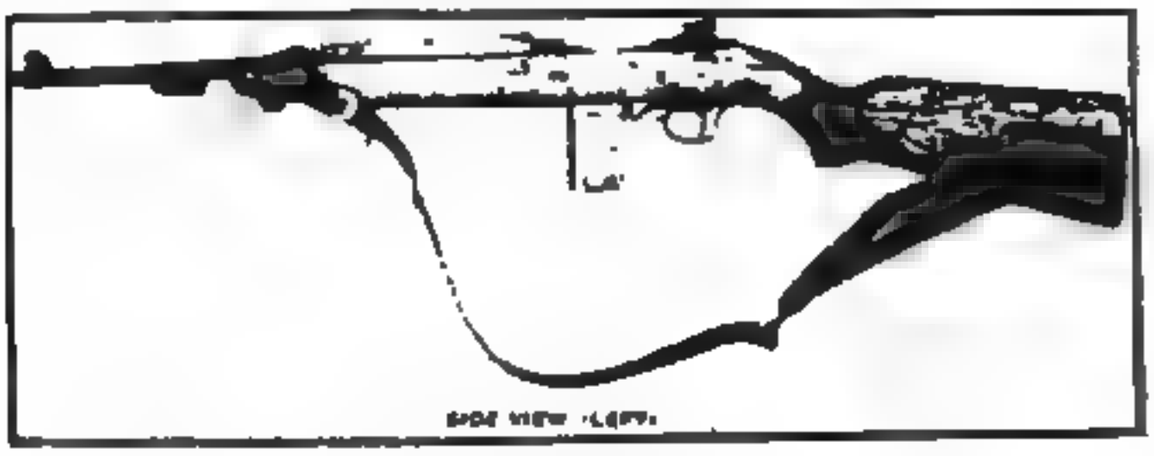


Figure 1 Carbine Cal .30, M1 & M2

1. Characteristics:

a. Air cooled
b. Magazine loaded
c. Gas operated
d. Semi and fully automatic
e. Shoulder weapon

2. Data:

a. Magazine capacity (15 & 30 rds)
b. Maximum range (2,208 yds)
c. Maximum effective range (275 yds)

V-2

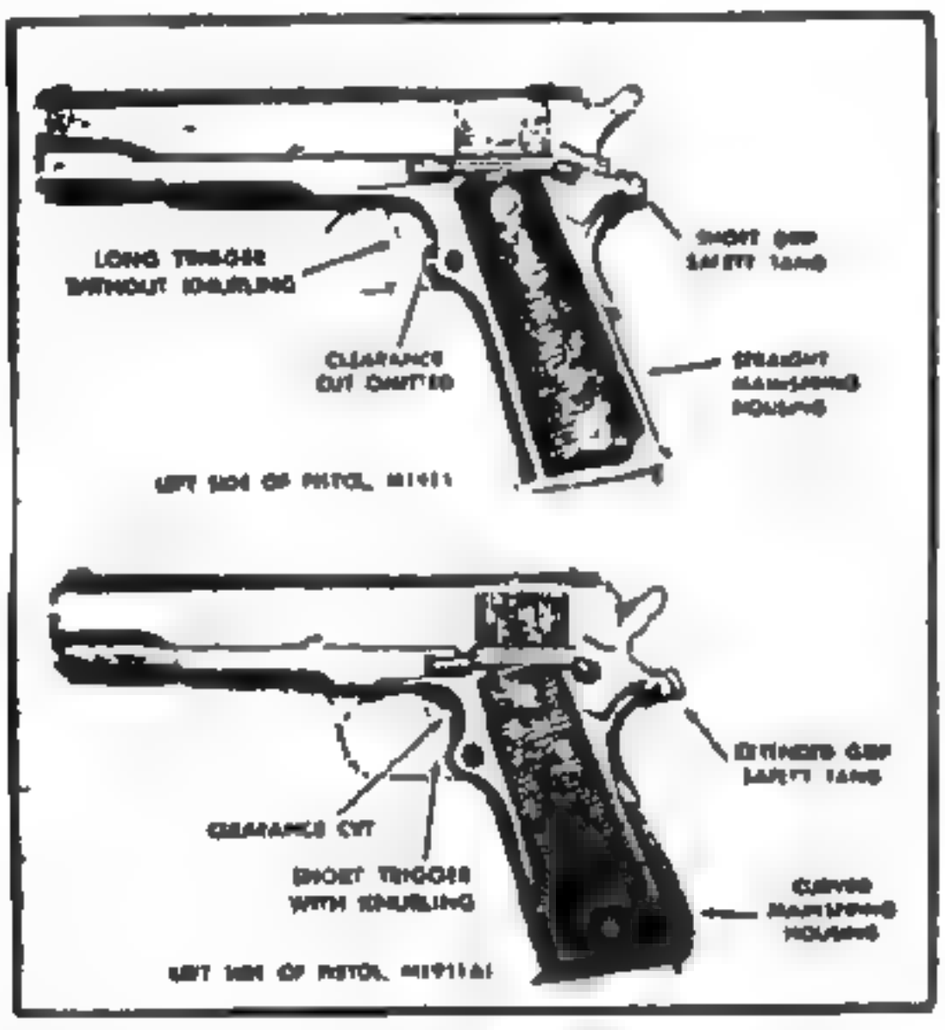


Figure 2 Pistol Cal .45 M1911 and M1911A1

1. Characteristics:

a. Recoil operated
b. Semi-automatic
c. Magazine Fed
d. Air cooled
e. Hand weapon

2. Data:

a. Maximum range (1,500 meters)
b. Effective range (50 meters)

1. Characteristics:

a. Air cooled
b. Blowback operated
c. Semi or fully automatic
d. Shoulder weapon
e. Magazine fed

2. Data:

a. Cyclic rate of fire (600-725 rpm)
b. Maximum effective range (100 meters)
c. Maximum range (1,600 meters)

V-4

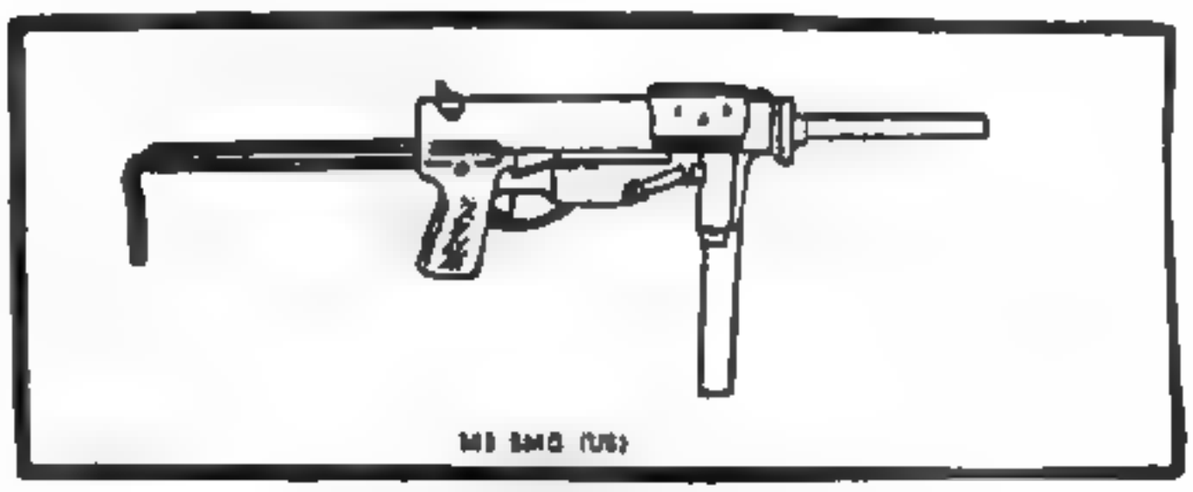


Figure 6 Submachine Gun M-3

1. Characteristics:

a. Air cooled
b. Blowback operated
c. Automatic
d. Shoulder weapon
e. Magazine fed

2. Data:

a. Maximum range (1'00 yds)
b. Maximum effective range (100 yds)

V-5

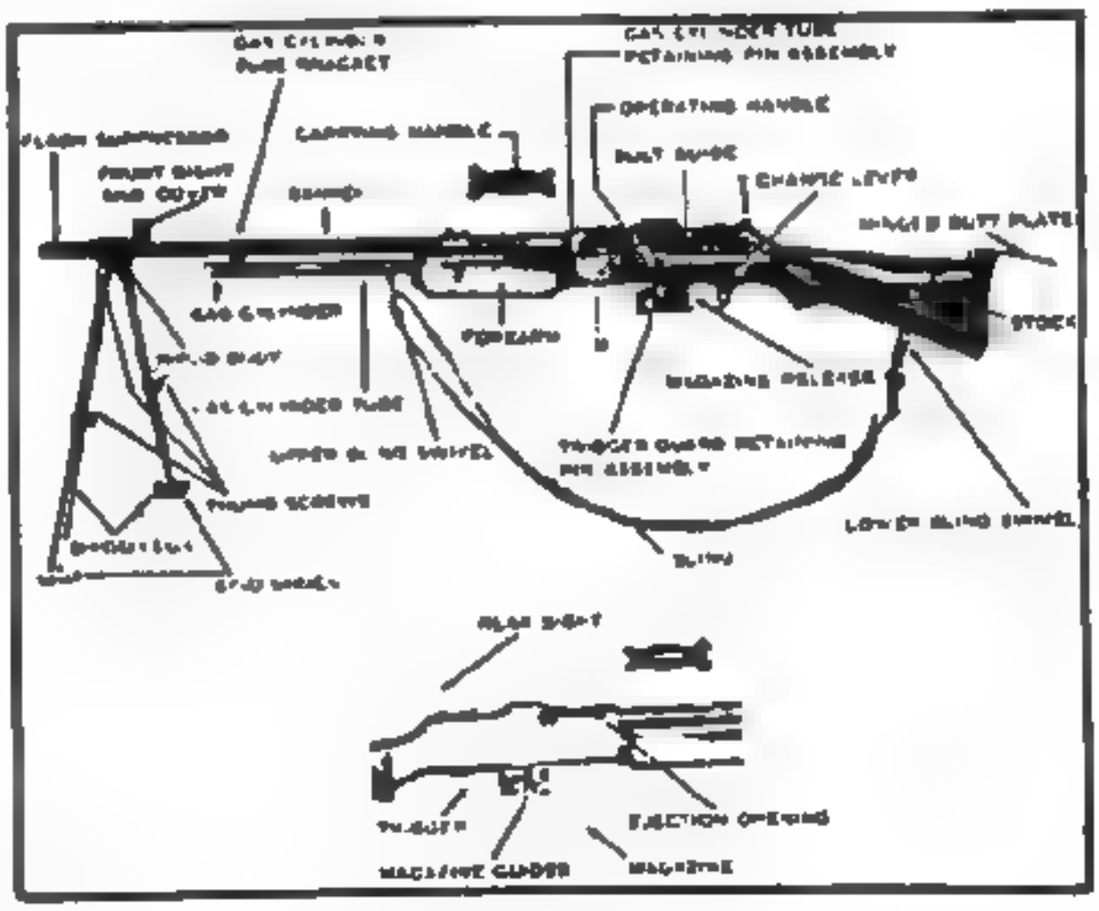


Figure 7 Browning Automatic Rifle M1918A2

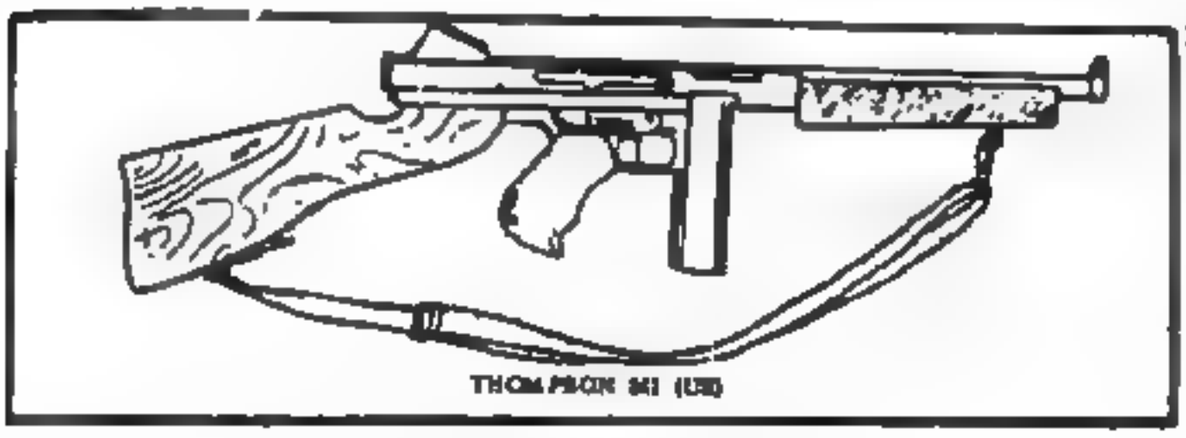


Figure 5 Thompson Submachinegun, M1A1 Cal .45

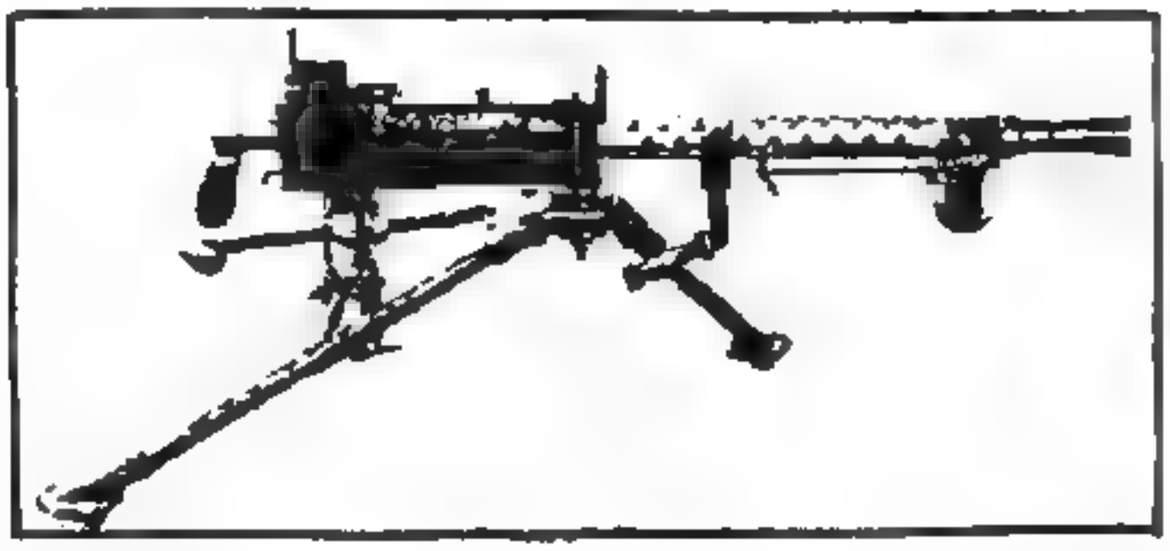
1. Characteristics:

a. Air cooled
b. Magazine fed
c. Shoulder weapon
d. Gas operated
e. Fully automatic

2. Data:

a. Range maximum (3,500 yds)
b. Range maximum effective (500 yds)

V-6



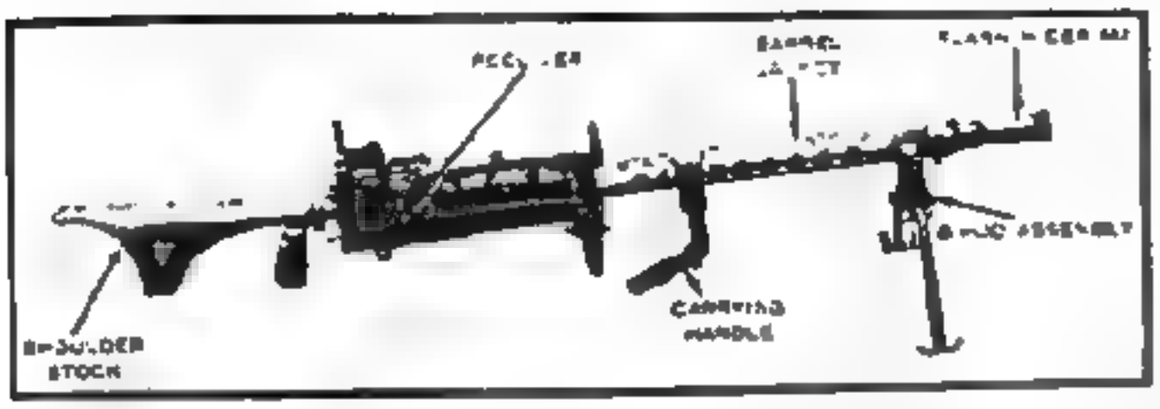


Figure 8 Browning Machine Gun Cal .30 M1919A6 on M2 mount (top) and on bipod (bottom).

1. Characteristics:

a. Belt-fed

b. Recoil operated

c. Air cooled

d. Fully automatic

2. Data:

a. Maximum effective range (2,200 [redacted]

b. Maximum range (3,500 yds)

c. Maximum rate of fire(600-675rpm)

d. Maximum effective rate of fire (150 rpm)

V-7

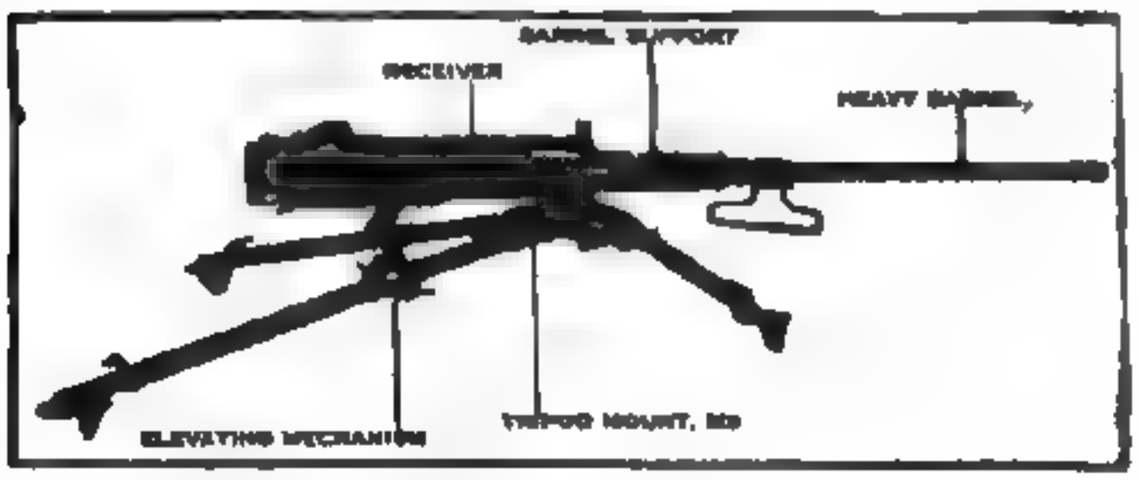


Figure 9 Browning Machine Gun Cal .50, M2, HB

1. Characteristics:

a. Air cooled

b. Recoil operated

c. Fully and semi-automatic

2. Data:

a. Maximum effective range (2,000 [redacted]

b. Maximum range (7,400 yds)

c. Maximum rate of fire (500 rpm)

d. Alternate feed (right and left)

e. Belt fed (metallic link)

V-8

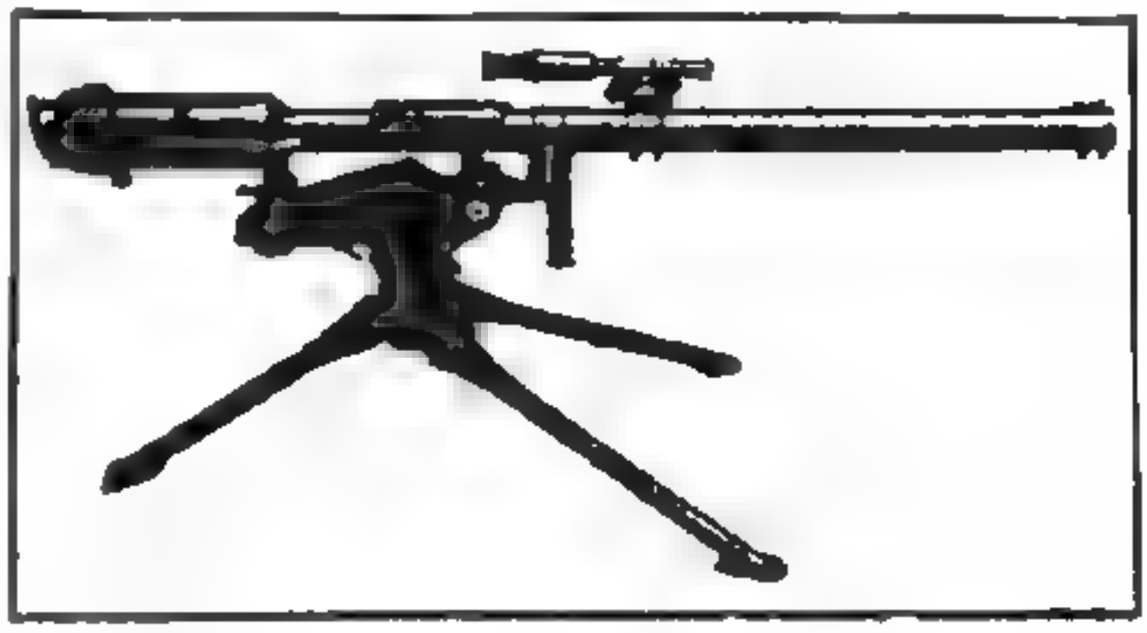


Figure 10 67 mm Recoilless Rifle M18A1

1. Characteristics:

a. Air cooled

b. Recoilless

c. Shoulder or mounted weapons

d. Single-loaded

e. Fires fixed ammunition

2. Data:

a. Maximum range (4800 yds)

b. Maximum effective range (1900 yds)

c. Bursting area (10 x 24 yds (HE) 17 yds radius (WP)

3. Safety:

The danger zone from back blast is triangular in shape. It extends approximately 80 feet to the rear of the point of emplacement and at its widest point covers a space of 20 feet on either side of the axis of the emplaced rifle. Do not face the weapon within 100 feet of the rear of its breech because of the danger of flying particles thrown up by the blast action. The following danger zone will be for all training:

V-9

For COMBAT USE the following may be used:

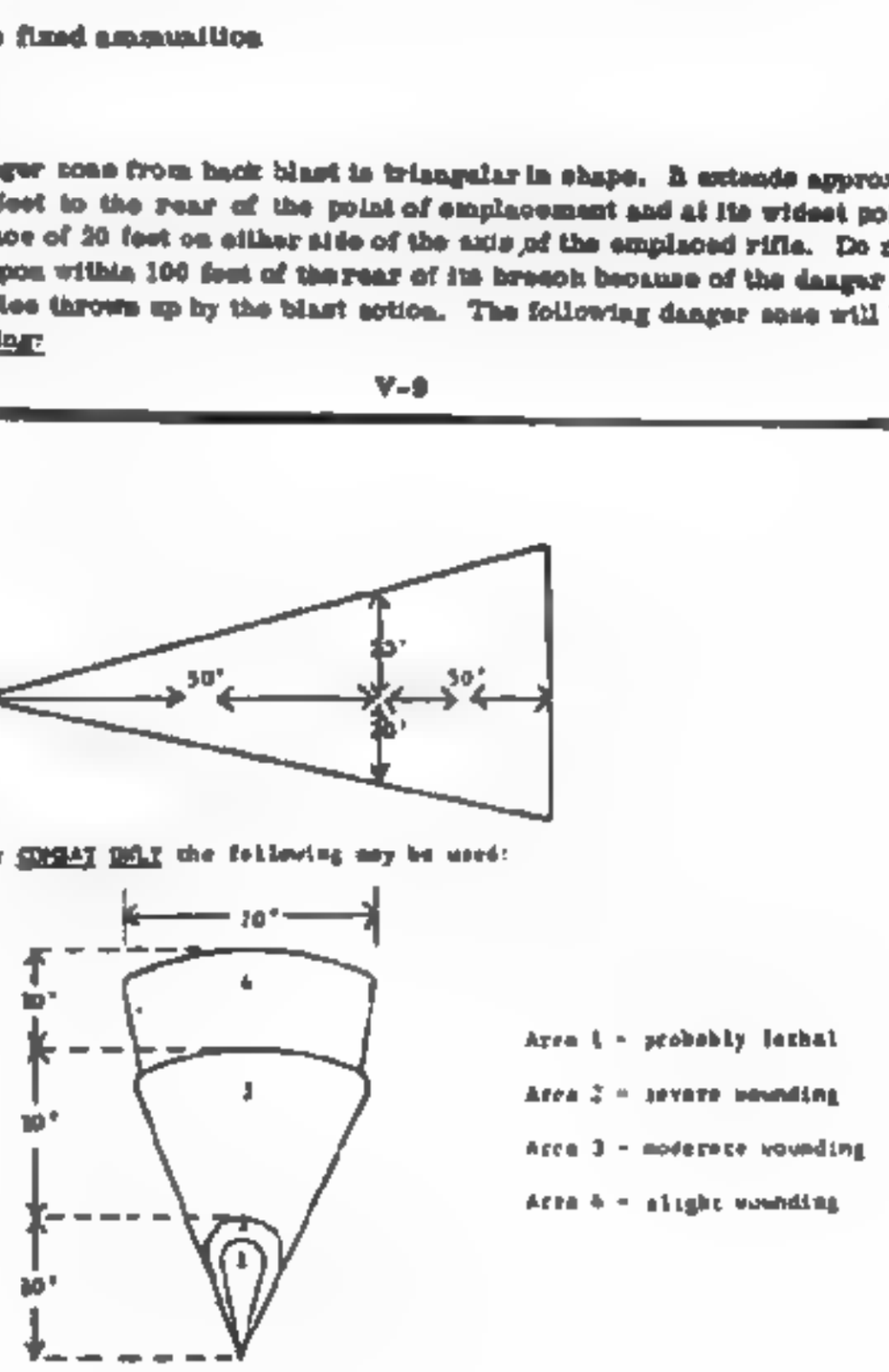


Figure 11

V-10

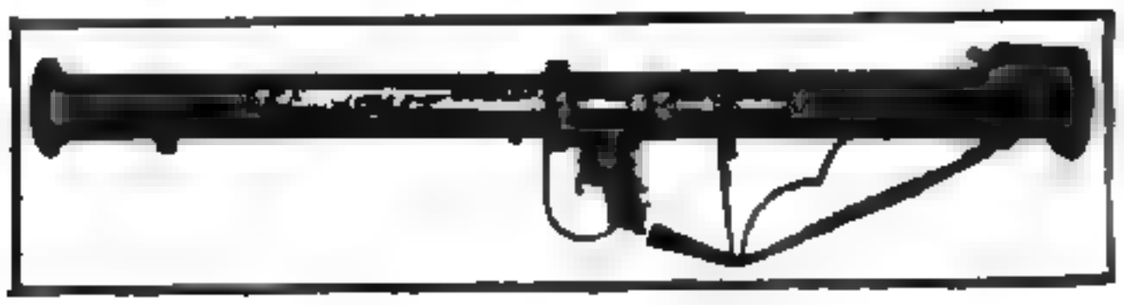


Figure 12, Rocket Launcher, 3.5-inch M20A1B1

1. Characteristics:

a. Air cooled

[redacted]

c. Open tube (2 pieces)

d. Recoilless

e. Shoulder weapon

f. Electrical firing mechanism

2. Data:

a. Maximum range (approx) (900 yds)

b. Maximum effective range (Moving-200 yds Stationary-300 yds)

c. Armor penetration (approx) (11 in)

d. Maximum rate of fire (12-15 rpm)

e. Sustained rate of fire (4rpm)

f. Bursting area approx (10x12 yds) (head)

[redacted]

a. All loading and unloading are done on the firing line with the launcher on the gunner's shoulder. The muzzle is potated down range, not toward the ground.

b. Face protection: For temperature below 75 degrees F, the field protective mask must be used. For temperatures above 75 degrees F, the anti-flash mask must be worn.

c. The weapon being of the recoilless principle has a danger zone to the rear. It is triangular in shape and consists of three zones. Before firing a rocket, clear the area to the rear of the launcher of personnel, material, and dry vegetation as indicated in zone A & B.

V-11

d. Clear zone A, the blast area, of all personnel, ammunition, materials, and inflammables such as dry vegetation. The danger in this zone is from the blast of flame to the rear. Clear zone B of personnel and material unless protected by adequate shelter. The principle danger in zone B is from the rearward flight of nozzle closure and/or igniter wires. An additional safety factor for training is contained in zone C.

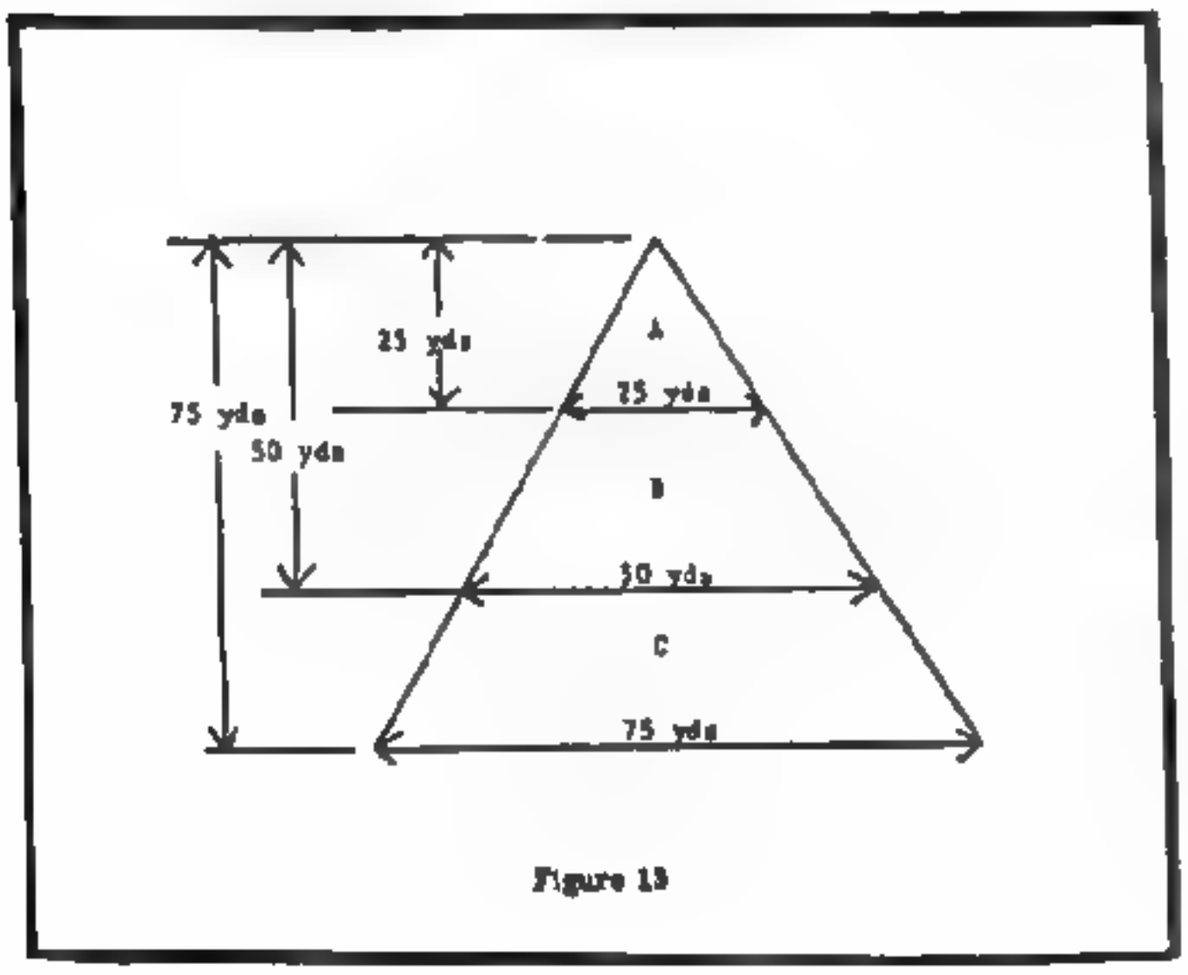


Figure 13

V-12

Figure 14 Mortar 60 mm, M-19

1. Characteristics:

a. Smooth bore

b. Muzzle loaded

c. High angle-of-fire weapon

2. Data:

a. Maximum rate of fire (30rpm)

b. Sustained rate of fire (18 rpm)

c. Bursting area (111yd radius (HE & WP))

V-13

Figure 15 Mortar 81 mm, M29

1. Characteristics:

a. Smooth bore

b. Muzzle loaded

c. High angle-of-fire weapon

d. Drop fire

2. Data:

a. Maximum rate of fire (24 rpm)

b. Sustained rate of fire (3 rpm)

c. Maximum range (4,000 yds)

d. Bursting area (30 x 20 yds)

V-14

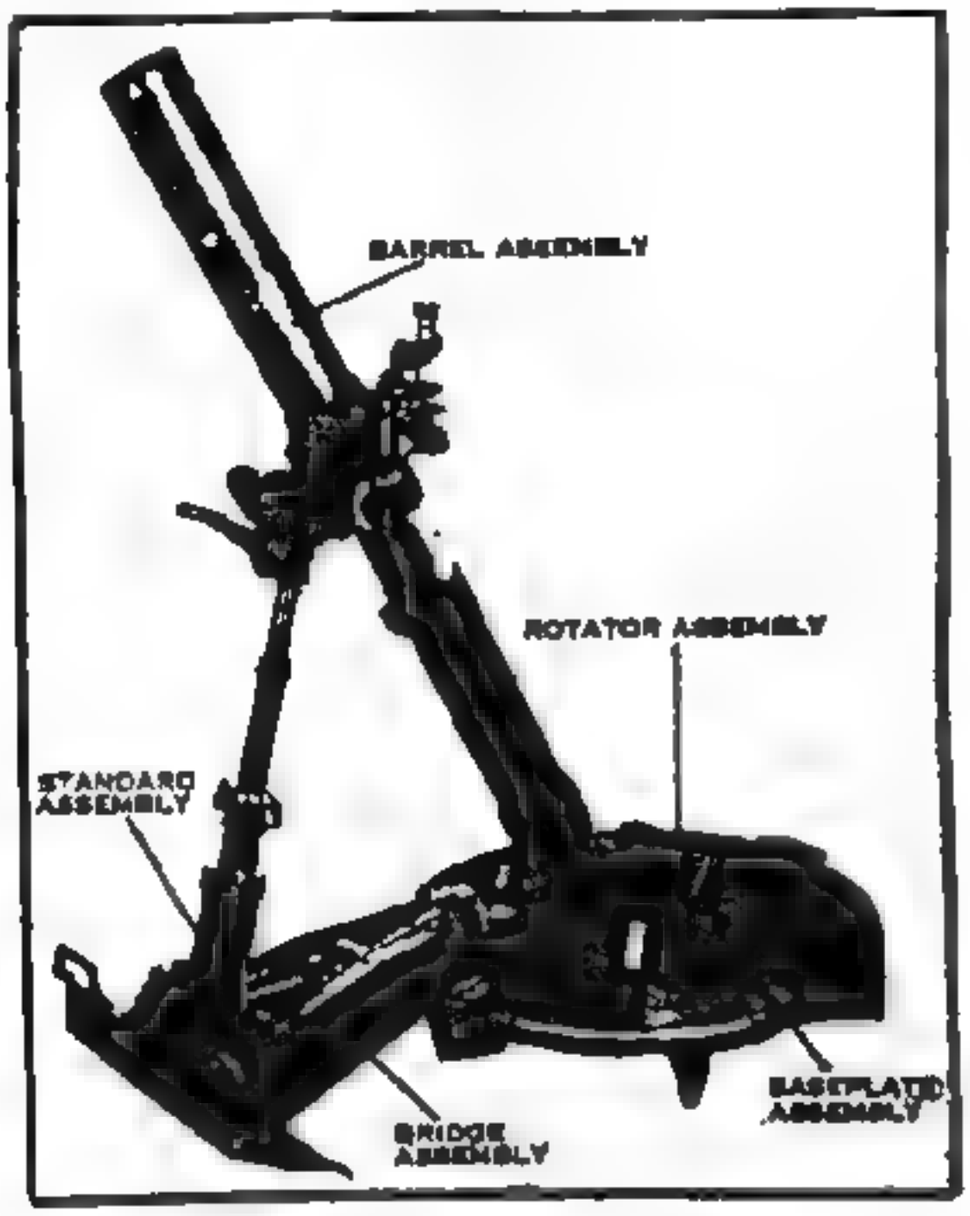


Figure 16 4.2" Mortar M30

1. Technical Data Characteristics:

a. Maximum range	5000 yds or 5500 m
b. Muzzle velocity	960 fps
c. Type of ammunition	HE, ILL and CHEM semifixed complete fix
d. Rate of fire	20 per min prolonged fire

V-16

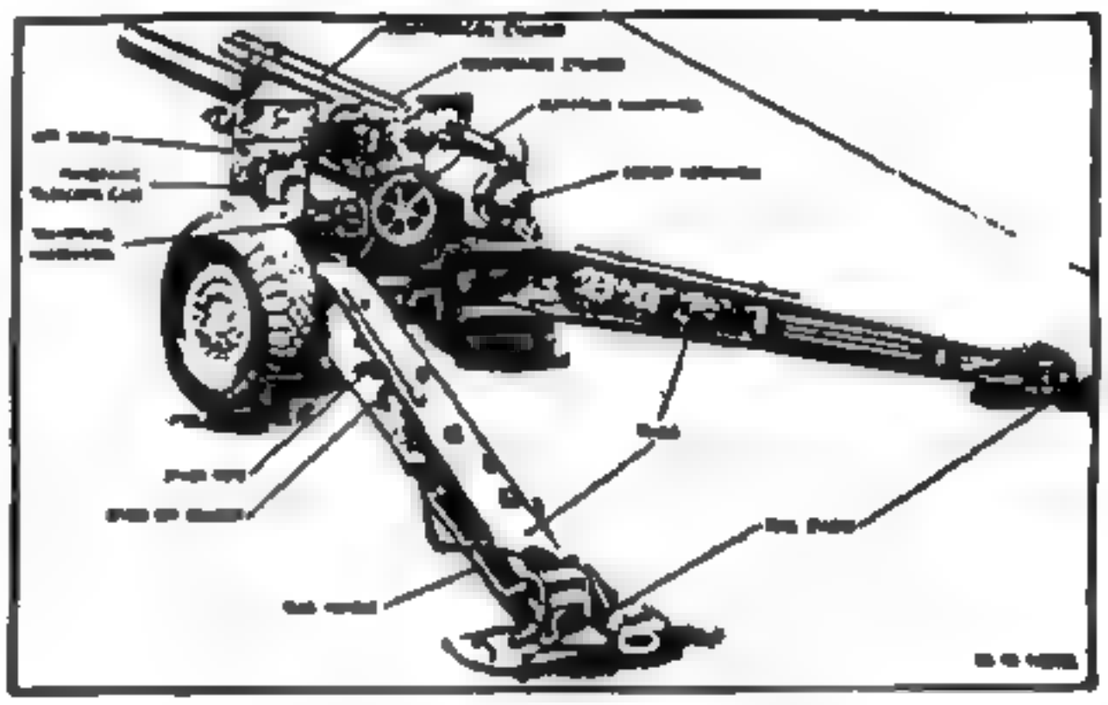


Figure 16 155 mm Howitzer, M114 or M114A1

1. Technical Data and Characteristics:

a. Maximum range	14,965 meters
b. Muzzle velocity	1850 fps w/ch 7
c. Type of ammunition	HE, ILL and CHEM, separate loading
d. Rate of fire	Rapid fire - 3 rds per min Prolonged fire- 1 rd per min

V-17

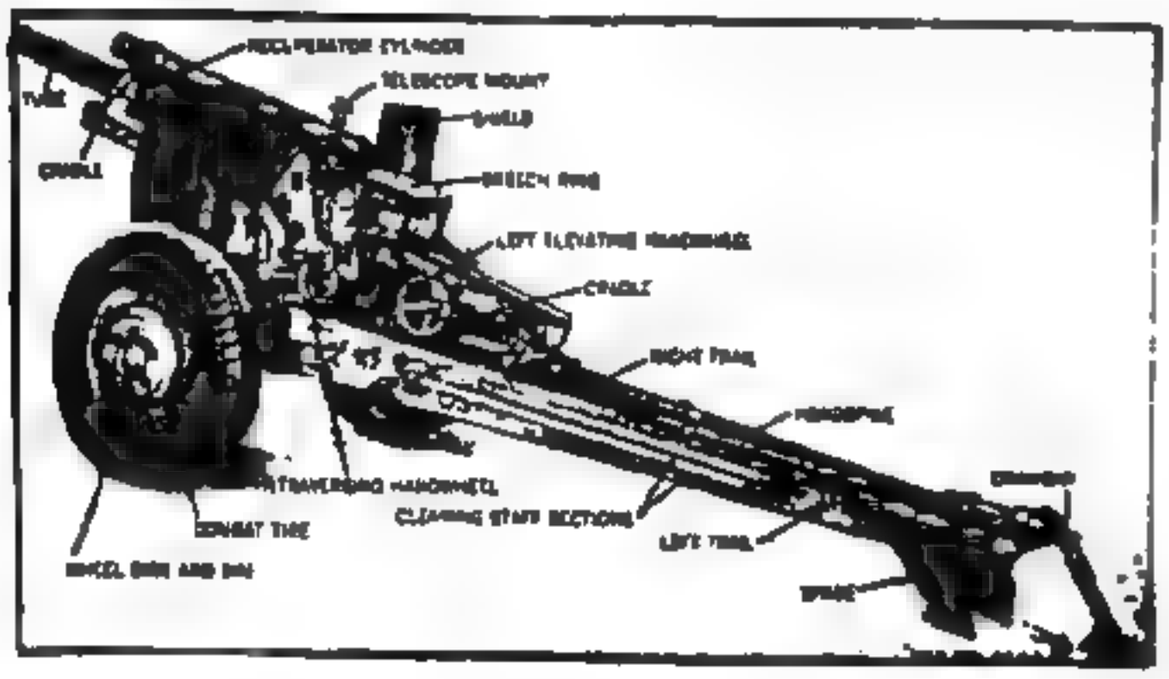


Figure 17 105 mm Howitzer M101

I. IMPROVISED RANGES.

[redacted]

1. Kind required by the training mission.
2. Travel time from camp to training area.
3. Security of training area.
4. Permission for use of area.
5. Safe impact area (Clear before each firing).
6. Terrain allows proper fields of fire for training to be conducted.
7. Vegetation in range area.
8. Materials available.
9. Labor and time available.

b. Shooting Gallery.

1. This is an introductory range to give the trainee practice in engaging a target with speed and accuracy.

2. Various targets such as bottles, plates, etc., of various colors and shapes are placed in clear view of the firer are at various angles from the firer. He is then instructed to engage targets by commands, giving direction and target. Example, "Right red can."

3. The firer is scored by number of hits and his speed in engaging the correct target.

4. Normally 3 seconds are allowed for each target; however, the instructor may vary this if the degree of training of his students so require.

V-18

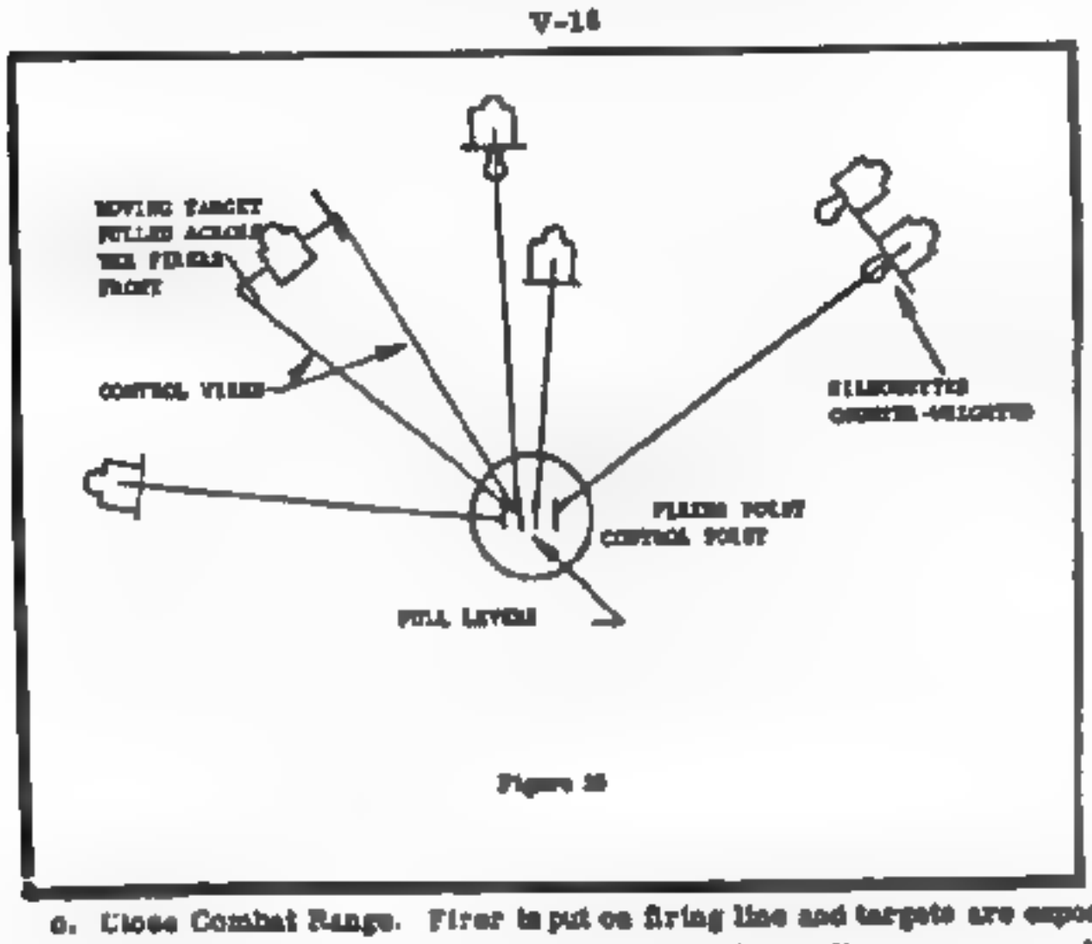


Figure 10

c. Close Combat Range. Firer is put on firing line and targets are exposed for short periods of time. Firer engages target upon its appearance and is scored for hits and handling of weapon.

V-19

d. MD Range.

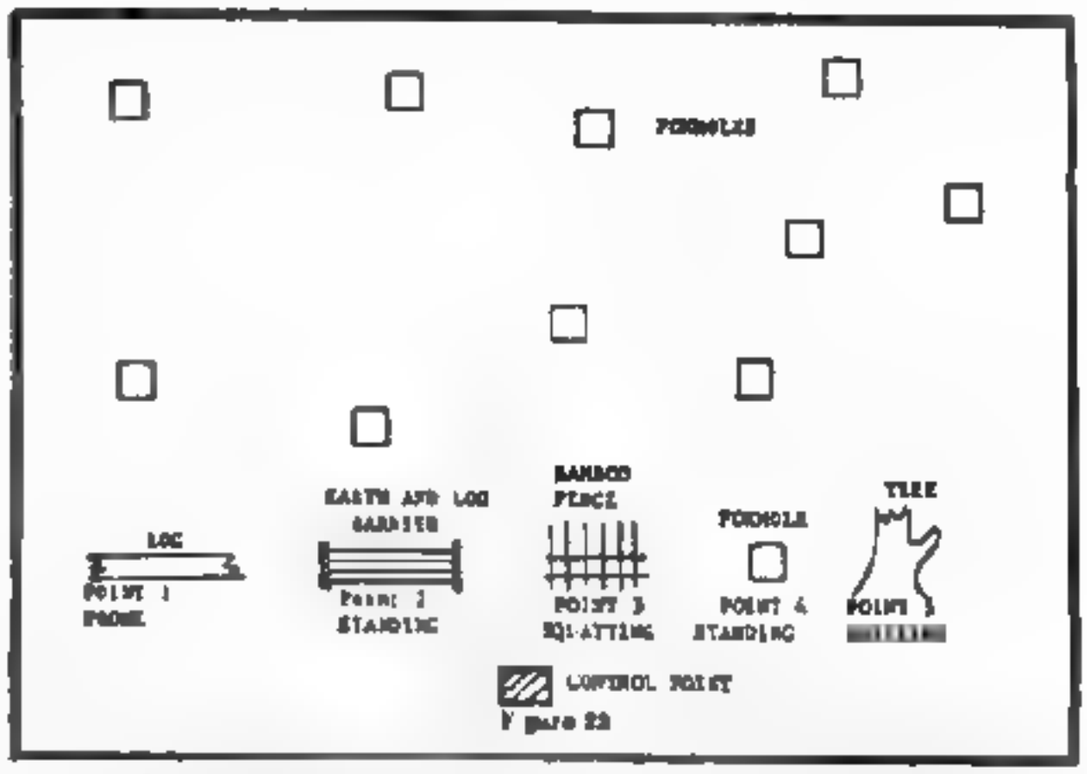
a. Ditch (#1) dug deep and wide enough to obtain sufficient fill for building up firing positions, (#2) all ditches drained to right or left of range.

b. Firing positions elevated and graded to permit drainage and clear fields of fire to the target line, from the prone positions.

Figure 11

V-20

e. Transition Range.



1. Personnel are put into foxholes down range with silhouettes on poles. These foxholes must be dug deep enough to afford the operator protection. The range from firing point to target will be determined by your training program.

2. Personnel firing make up the designed position. When ready the range officer blows a whistle and all targets are exposed to the firer. The firer engages targets in his lane. After a designated time a signal is given and targets are lowered. All targets when hit will be lowered immediately.

3. Scoring may be accomplished by allowing so many points for each target hit and so many points for each unexpended round.

V-21

f. Jungle Lane.

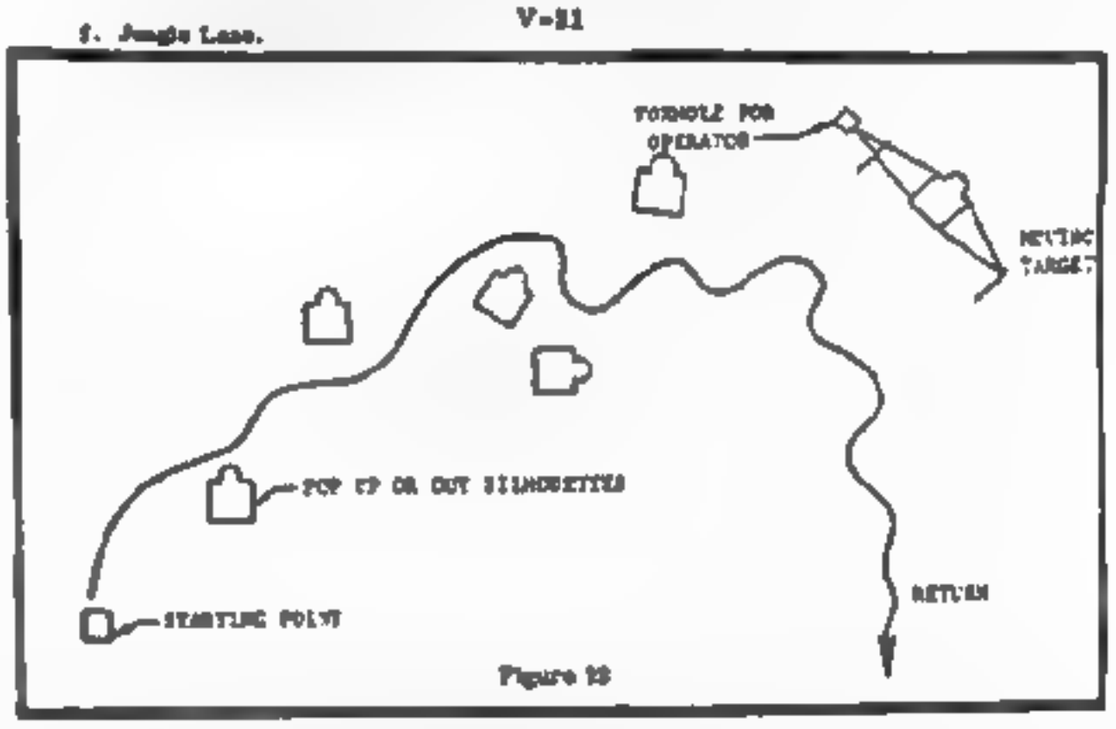


Figure 12

1. This range may be used by individual firers or a small patrol. Targets are placed so they become exposed as the trainee rounds a bend or passes a thicket, etc. He will engage the target as soon as he observes it.

2. Trainee is scored on his detection, accuracy, and handling of weapon

V-22

g. Immediate Action Range.

1. This range may be employed for either vehicle or foot IA drill.

2. Scoring may be accomplished by allowing so many points for each target hit and so many points for each unexpended round.

2. A pathor road is selected with one or more good ambush sites on it. At one or more of these sites at least two foxholes are dug to accomodate two personnel each. These must be camouflaged from the trail or road. A silhouette target on a pole and an automatic weapon is placed in each foxhole. Additional targets which cannot be observed from road or trail but will be observed as the training unit deploys may be placed.

3. The trainees, organized in squad or larger units, are directed down the trail or road. When the instructor desires to trigger the ambush the automatic weapons in the foxholes open fire into a safe impact area and the silhouette targets are raised. The training unit then deploys, using the desired IA drill, engaging the target with live fire.

4. The instructor must exercise various safety measures as designating zones of fire and limiting points for deploying units.

V-23

h. Ambush Range.

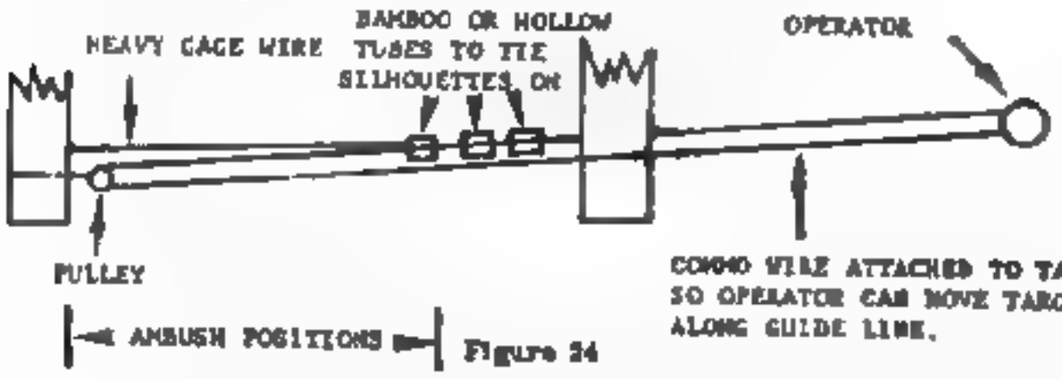


Figure 24

1. This range should be built in vegetation such as the trainee will be operating in, with vegetation being left in place to make trainee select clear spaces to fire through.

2. A squad or similar size unit takes up an ambush position and the targets are then moved into the killing area. Targets are engaged at the ambush leader's signal.

3. Scoring can be accomplished by members of him, triggering of ambush at most opportune time, distribution of fire and individual reaction.

E. EXAMPLES OF TARGET CONSTRUCTION

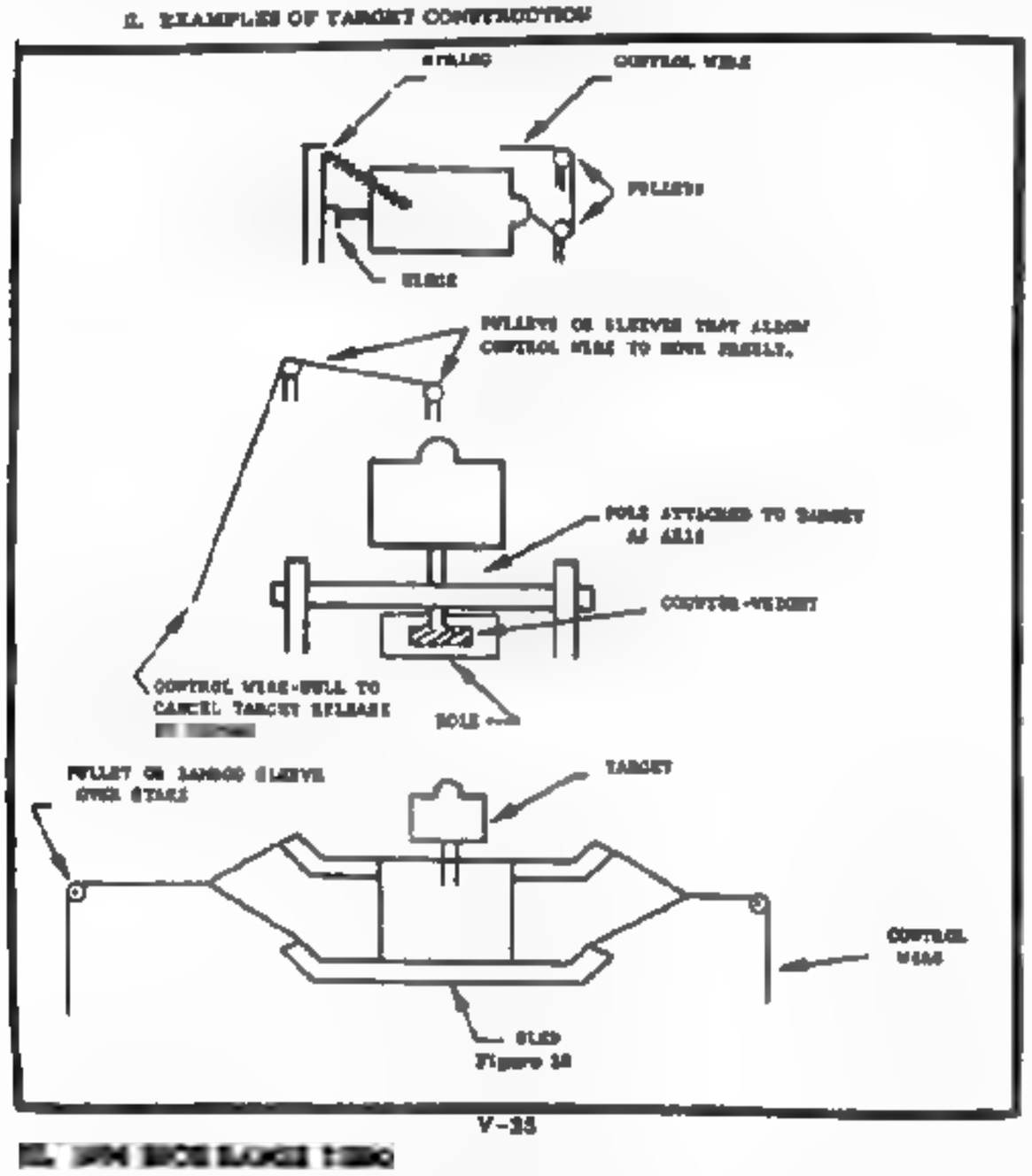


Figure 25

F. [illegible] RANGE 1:250

a. To zero the rifle for 300 yards (battle sights), ... shot group shou... 1-1/4 inches above the point of aim at 1,000 inches.

b. This sight setting enables the soldier to hit his point of aim at a range of 300 yards.

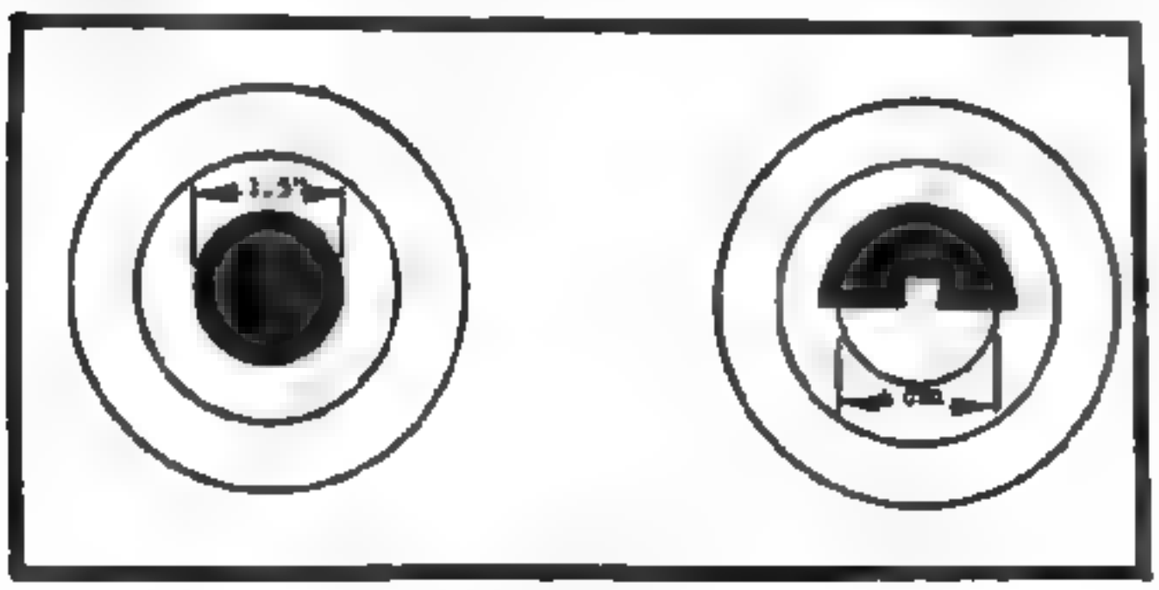


Figure 26 1,000 inch target and 25 meter target

IV. 25 METER RANGE ZERO.

a. To zero the rifle for 250 meters (battle sight), the shot group should be at the point of aim at 25 meters.

b. This sight setting enables the soldier to hit his point of aim at a range of [illegible] meters.

V. WIND FORMULA.

To determine the clicks for full wind:

R (Range to target in hundreds rds) times V (wind velocity MPH)
15 (constant factor)

V-26

VI. WORM FORMULA (any unit of measurement)

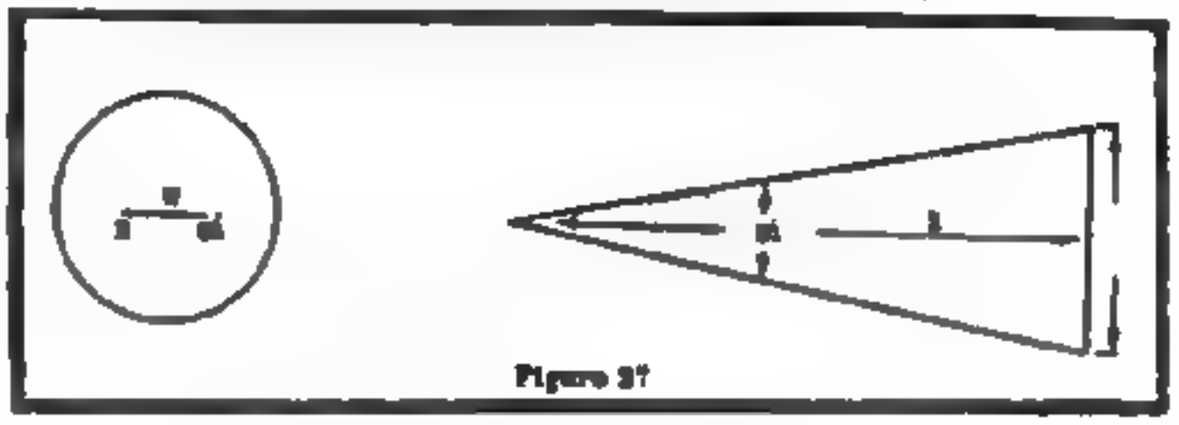


Figure 27

One mil equals one at a range of one thousand.

W = Width	To find W multiply R times mil
R = Range in thousands	To find R divide W by mil
Mil = Mils	To find Mil divide W by R

VII. WIND VELOCITY CHART.

a. Degree of angle (flag, handkerchief, etc) MPH Wind

15	5
30	10
50	15
60	20
70	25
80	30

b. Rule of Thumb Wind Velocity Formula. Hold paper, dust, or grass at arm's length and let it drop. Point to where it lands. Divide the angle between the arm extended and the body by four to get the MPH wind velocity.

CHAPTER 6

COMMUNICATION

PHONETIC ALPHABET AND INTERNATIONAL MORSE CODE

Letter	Word	CW Code	Letter	Word	CW Code
A	ALFA	•—	G	GOLF	——•
B	BRAVO	—•••	H	HOTEL	••••
C	[illegible]	—•—•	I	INDIA	••
D	DELTA	—••	J	JULIETT	•———
E	ECHO	•	K	KILO	—•—
F	FOXTROT	••—•	L	LIMA	•—••

M	MIKE	--	**T**	TANGO	-
N	NOVEMBER	-.	**U**	UNIFORM	..-
O	OSCAR	---	**V**	VICTOR	...-
P	PAPA	.--.	**W**	WHISKEY	.--
Q	QUEBEC	--.-	**X**	XRAY	-..-
R	ROMEO	.-.	**Y**	YANKEE	-.--
S	SIERRA	...	**Z**	ZULU	--..

NUMERALS

1	.----	4	....-	7	--... 0	-----
2	..---	5	.....	8	---..
3	...--	6	-....	9	----.

VI-1

PROWORDS AND PROSIGNS

PROWORD	PROSIGN	DEFINITION
THIS IS	DE	This transmission is from the station whose designation immediately follows.
OVER	K	This is the end of my transmission and a response is necessary. Go ahead; transmit.
OUT	$\overline{AR}$	This is the end of my transmission and no answer is required. (Since OVER and OUT have opposite meanings, they are never used together.)
ROGER	R	I have received your last transmission satisfactorily.
SAY AGAIN	$\overline{IMI}$	Repeat all of your last transmission.
I SPELL		I shall spell the next word phonetically.
CORRECTION	EEEEEEE	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted.
[redacted]		A message which requires recording is about to follow.
[redacted]		I have received your message, understand it and will comply. (To be used only by the addressee. Since the meaning of the proword ROGER is included in that of WILCO, the two prowords are never used together.)
I SAY AGAIN	$\overline{IMI}$	I am repeating transmission or portion indicated.
BREAK	$\overline{BT}$	I hereby indicate the separation of the text from other portions of the message.
[redacted] TIME		That which immediately follows is the time or date/time group of the message.
WAIT	$\overline{AS}$	I must pause for a few seconds.
WAIT OUT	$\overline{AS}$ $\overline{AR}$	I must pause longer than a few seconds.
GROUPS	GR	This message contains the number of groups indicated by the numeral following.
READ BACK	G	Repeat this entire transmission back to me exactly as received.
[redacted]		The following is my response to your instructions to read back.
THAT IS CORRECT	C	What you have transmitted is correct.
WRONG		Your last transmission was incorrect. The correct version is ____ ____.
RELAY (TO)	T	Transmit this message to all addressees or to the address designations immediately following.
ALL AFTER	AA	The portion of the message to which I have reference is all that follows____.
ALL BEFORE	AB	The portion of the message to which I have reference is all that precedes____.
FROM	FM	The originator of this message is indicated by the address designation immediately following.
TO	TO	The addressee(s) whose designation(s) immediately following are to take action on this message.
SPEAK SLOWER		Reduce speed of transmission.
WORDS TWICE		Transmit(ting) each phrase (or each code group) twice.
[redacted]		Verify entire message (or portion indicated) with the originator and send correct version. (To be used only at the discretion of or by the addressee to which the questioned message was directed.)
I VERIFY		That which follows has been verified at your request and is repeated. (To be used only as a reply to VERIFY.)
SILENCE	$\overline{HM}$ $\overline{HM}$ $\overline{HM}$	"Silence" spoken three times means "Cease Transmission Immediately." Silence will be maintained until instructed to resume. Transmissions imposing "Listening" silence must be authenticated.
SILENCE LIFTED	ZUO $\overline{HM}$ $\overline{HM}$ $\overline{HM}$	Resume normal transmission. (Silence can be lifted only by the station imposing it or by a higher authority. When an authentication system is in force, transmission lifting "listening" silence must be authenticated.
SERVICE	SVC	The message that follows is a service message.
DO NOT ANSWER	F	Stations called are not to answer this call, receipt for this message or otherwise to transmit in connection with this transmission. (When this proword is employed, the transmission shall be ended with the proword OUT.)
DISREGARD THIS TRANSMISSION		This transmission is in error. Disregard

VI-3

	EEEEEEEE $\overline{AR}$	it. (This proword shall not be used to cancel any message that has been completely transmitted and for which receipt or acknowledgment has been received.

VI-4

FLASH	Z	Precedence FLASH. (Reserved for initial enemy contact reports or special emergency operational combat traffic.)
IMMEDIATE	O	Precedence OPERATIONAL IMMEDIATE. (Reserved for important TACTICAL messages pertaining to the operation in progress.)
PRIORITY	P	Precedence PRIORITY. (Reserved for important messages which must have precedence over routine traffic.)
ROUTINE	R	Precedence ROUTINE. (Reserved for all types of message which are not of sufficient urgency to justify higher precedence, but must be delivered to the addressee without delay.)
FIGURES		Numerals or numbers follow. (Optional)
EXEMPT	XMT	The addressee designation immediately following are exempted from the collective call.
INFO	INFO	The addressee designation immediately following are addressed for information.
UNKNOWN STATION	$\overline{AA}$	The identity of the station with whom I am attempting to establish communication is [redacted]
GROUP NO COUNT	GRNC	The groups in this message have not been [redacted]
EXECUTE	$\overline{DX}$ 5 Sec Dash	Carry out the purport of the message or signal to which this applies. (To be used only with the executive method.)
EXECUTE TO FOLLOW	$\overline{\quad}$ [redacted]	Action on the message or signal which follows is to be carried out upon receipt of the proword "EXECUTE." (To be used only with the executive method.)

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OPERATING SIGNALS

QRA	Station Name
QRK	Readability
QRL	Are you busy
QRM	I am being interfered with
QRN	I am troubled with static
QRQ	Send faster
QRS	Send slower
QRU	Nothing for you
QRV	Ready
QRX	I will call again at
QRZ	You are called by
QSA	Signal strength
QSB	Signals fading
QSD	Your key is defective
QSL	Acknowledge receipt
QSV	Send V's
QSY	Change transmitting frequency
QSZ	Send groups twice
QSW	I am going to transmit on frequency
QTB	Check you group count
ZBO	Message for you
ZKB	Take control of net until
ZKE	Reporting into net
ZKJ	Close down until
ZUE	Affirmative
ZUG	Negative
ZUH	Unable to comply
ZUJ	Stand by
ZXU	Unable to decipher
ZXV	Check encipherment

VI-6

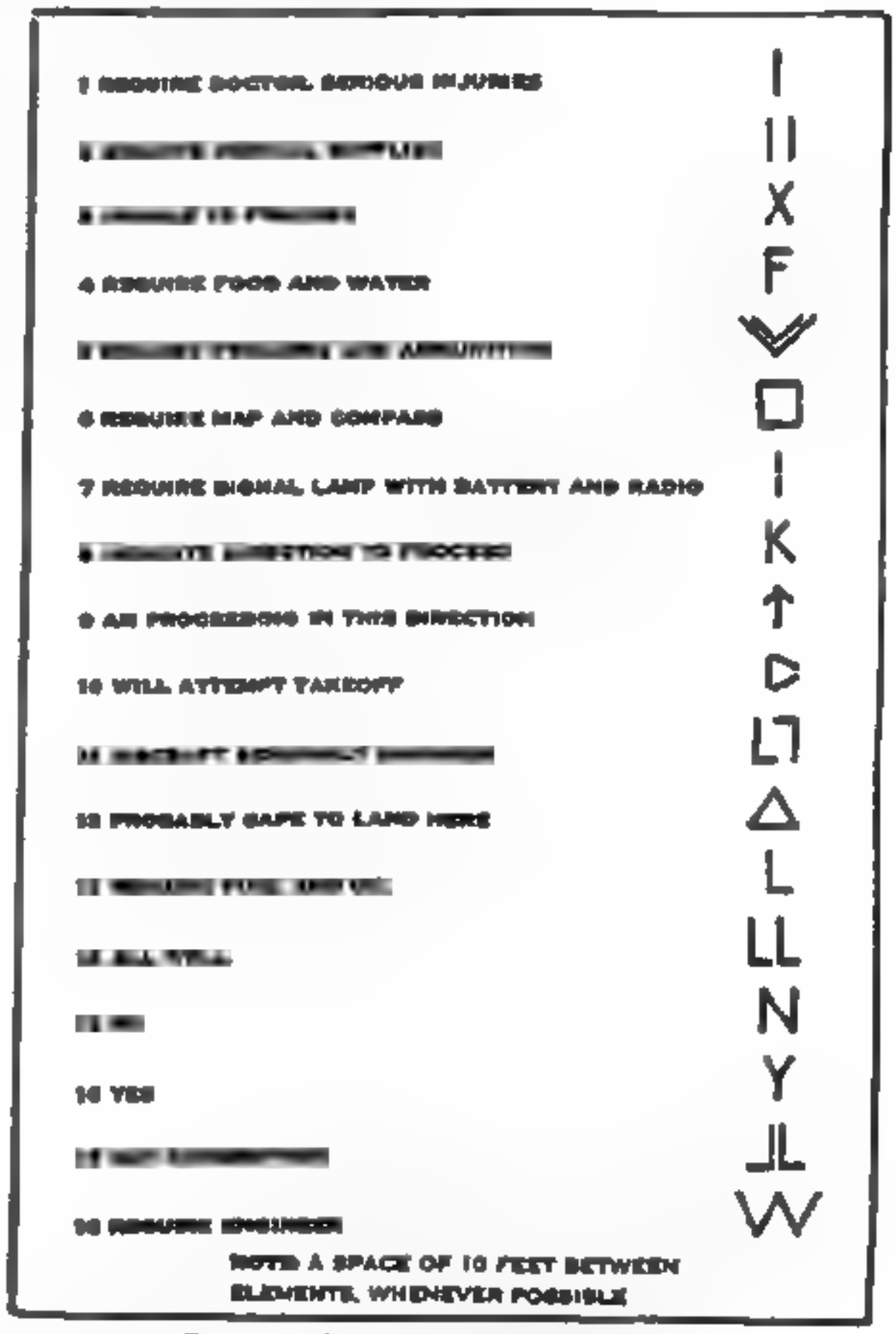

Figure 1 Ground-Air Emergency Code

VI-7

I. COMMUNICATOR'S CHECK LIST.

a. Radios

1. High Ground (FM).
2. Clearing with no obstructions (FM).
3. Antenna oriented with receiving station, clear of obstructions (AM).

4. Radio camouflaged properly.

5. Radio set properly grounded (AM).

6. Security around radio site.

7. Transmitting site moved, using around the clock method, but not going in a circle (AM).

8. Antenna properly loaded (AM).

9. Transmitter and Receiver on proper frequency.

10. Secret documents not at radio site.

11. Message encrypted currently (AM).

12. Radio site sterilized after departure.

b. Visual Signals:

1. Signals properly placed so as to be easily read.

2. Signals simple and brief.

3. Operator properly oriented on signals and procedures.

4. Signalling device within range of receiver's vision.

5. Signals not too obvious.

6. Alternate signals.

c. Audio Signals:

1. Easily understandable.

2. Clear and loud.

3. Signals related to surrounding noises.

[redacted]

5. Signals simple and clear.

6. Alternate signals included.

d. Message Center:

1. Message center established.

2. All incoming and outgoing messages logged.

3. Code (and alternate code) made up for internal use.

4. Encrypting checked before transmission.

II. RADIO NETTING CONSIDERATIONS.

a. When planning a radio net certain technical factors must be considered in connection with the equipment available. They are:

1. Emission-Are the radios compatible? Are all radios going to operate voice or CW?

2. Frequency-Can the radios operate within the same frequency band?

3. Modulation-AM works only with AM, FM only with FM.

4. Range - Do not plan a net beyond the transmission range of the weakest set.

5. Crystals - Are proper crystals on hand if needed.

6. Terrain - Are appropriate high points available for radio stations if line of sight communications are planned.

b. Operating factors to consider are:

1. Schedule of operation.

2. Proficiency of operators.

3. Communications security.

(a) Physical security of codes ciphers.

(b) Cryptographic security and operating information (SOI).

(c) Transmission Security.

TABLE NR. I AN/GRC - 109 - PREPARATION FOR OPERATION

1. Connect appropriate power supply to power source.

2. Connect transmitter and receiver to appropriate power supply or source.

3. Connect a lead 25 feet or less to the ground post of transmitter and a good ground. (If good ground is not available utilize a counterpoise).

4. Connect a lead from "RCVR ANT" on transmitter to "ant" on receiver.

5. Connect a lead from "RCVR GRD" on transmitter to "grd" on receiver.

6. Connect antenna to "ANT" post on transmitter. Select proper length of antenna to correspond with operating frequency. Antenna must be at least one quarter wave length long. Radio Set AN/GRC-109 will load properly on any fed single line antenna that is exactly 1/2 wave length or any multiple thereof. To provide for a better indication in the antenna load lamp, the physical length of the wire may be adjusted ± 10 percent.

7. Set tuning dial on receiver to receiving frequency.

8. Check tuning chart on front of transmitter and turn controls to the settings indicated.

9. Turn all controls on transmitter in proper sequence for maximum glow on the indicator lamps. (Retune the first lamp slightly to prevent a chirping signal from being emitted.)

10. Connect headset to terminals on the receiver and adjust gain for desired level.

11. Turn the beat frequency oscillator control to the ON position for CW reception and adjust for desired tone.

12. Power Supplies (that have power control):

a. Large Power Supply PP-3694 (AC-DC).

b. Small Power Supply PP-3695 (AC only).

c. Voltage Regulator CN-468 (G-43/U only).

13. Power Sources:

a. AC voltage 95 - 265 VAC @ 45 - 450 cps (with PP-3694 or PP-3695).

b. 6 volt wet cell battery (with PP-3694).

c. Hand generator G-43/G (with PP-3694, CN-468, or direct to transmitter).

d. Gas Generator AN/UGP -19 (with PP-3694 or PP-3695).

e. Dry Battery BA-317 or BA-48 (direct to receiver).

TABLE NR. II AN/GRC-34, 87, AN/VRC-34, PREPARATION FOR OPERATION

1. OFF SEND STANDBY switch to STANDBY.

2. PHONE CW NET CAL switch to CAL.

3. PHONE MCW CW switch to PHONE

4. A.F. gain control fully clockwise to STOP.

5. R.F. gain control fully counter clockwise (OFF).

6. Band switch to appropriate band.

7. Turn receiver tuning control to crystal check point nearest desired frequency. Increase R.F gain control slightly until signal is heard. Adjust receiver tuning control until zero beat is heard as the strongest beat note in the vicinity of the crystal check point. Keep R.F. gain control adjusted to the point where the beat note is just audible.

8. PHONE CW NET CAL switch to NET.

9. PHONE MCW CW switch to CW Hi.

10. XTAL MO band switch to MO of appropriate band.

11. Refer to calibration chart, set transmitter tuning control to same frequency as now appears on the receiver dial.

12. OFF SEND STANDBY switch to STANDBY when using CN 18 and BA 317.

13. Adjust A.F. gain for the desired volume and turn R.F. gain to mid point.

14. Adjust OSC CAL control until zero beat is heard. (Do not close microphone or key while performing this step.) Power must be obtained at this time from the generator.

15. Refer to calibration chart and set transmitter tuning to desired operating frequency and lock tuning control.

16. Set receiver tuning control to desired operating frequency and tune receiver for zero beat with transmitter. Lock tuning control. Must obtain power from generator.

17. Set antenna selector control to the highest numbered position for the type of antenna being used. Close key or microphone and rotate the antenna tuning control until indicator glows and adjust for maximum glow.

18. Set receiver and transmitter switches for the desired type of transmission and reception.

19. The set is now ready for operation.

TABLE NR. III INTERPOLATION

1. A dial calibration chart appears on each AN/GRC 81.

2. Its purpose is to relate dial settings to transmitting frequencies.

3. The charts on each set are different.

4. The dial calibration chart will not give you the dial setting for unlisted frequencies . . .you must interpolate to find it.

5. Steps in interpolation:

a. Subtract the next lower frequency from the desired frequency.

b. Find the difference between the dial readings just above and just below the desired frequency.

c. Multiply the values obtained in these two steps.

d. If in band 2 or 3, divide by 20. If in band 1, divide by 50.

e. Add the results of step above to the dial setting for the next lower listed frequency. This is the correct dial setting for your desired frequency.

EXAMPLE: Desired frequency is 4487 kcs:

1. Subtract 4480 from 4487 = 7
2. Subtract 1471 from 1491 = 20
3. Multiply 7 by 20 = 140
4. Divide 140 by 20 = 7
5. Add 7 to 1471 = 1478 proper dial setting

Freq	.100 kc	.20 kc	.40 kc	.60 kc	.80 kc
		Band 2			
4480	[illegible]	[illegible]	[illegible]	1367	[illegible]
4400	1332	1412	[illegible]	1451	[illegible]
4500	1491	1511	1530	1550	1569

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TABLE NR. IV ANTENNA LENGTH CHART

FREQUENCY MEGACYCLE	FULL WAVE LENGTH	FREQUENCY MEGACYCLE	FULL WAVE LENGTH	FREQUENCY MEGACYCLE	FULL WAVE LENGTH
1	936	21	44.6	41	22.8
2	468	22	42.6	42	22.2
3	312	23	40.6	43	21.8
4	234	24	39	44	21.2
5	187.2	25	37.4	45	20.8
6	156	26	36	46	20 4
7	133.6	27	34.6	47	19 8
8	117	28	33.4	48	19 4
9	104	29	32.2	49	19
10	93.6	30	31.2	50	18 8
11	85	31	30.2	51	18.4
12	78	32	29.2	52	18
13	72	33	28.4	53	17.6
14	66.8	34	27.6	54	17 4
15	62.4	35	26.8	55	17
16	58.4	36	26	56	16 8
17	55	37	25.2	57	16.4
18	52	38	24.6	58	16.2
19	49.2	39	24	59	15 8
20	46.8	40	23.4	60	15.6

LENGTHS ARE IN FEET

VI-14

III. ANTENNA CONSIDERATIONS.

a. One of the most critical aspects of reliable radio transmission and reception is the proper design, utilization and location of transmitting and receiving [illegible]

b. Antennas should be "cut" the wave length of the frequency being used. Most of the time, however, this is not practical, so a 1/2 or 1/4 wave length antenna is used.

c. The formulas below should be used to determine desired antenna lengths.

1/4 wave = $\frac{234}{F}$

1/2 wave = $\frac{468}{F}$

1 wave = $\frac{935}{F}$

NOTE:

F is frequency in megacycles

Antenna Lengths are in feet

NOTE: When using radio set AN/GRC-109 with 1/2 wave length end fed antenna, the antenna may be adjusted by $\pm$ 10 percent of the exact wavelength

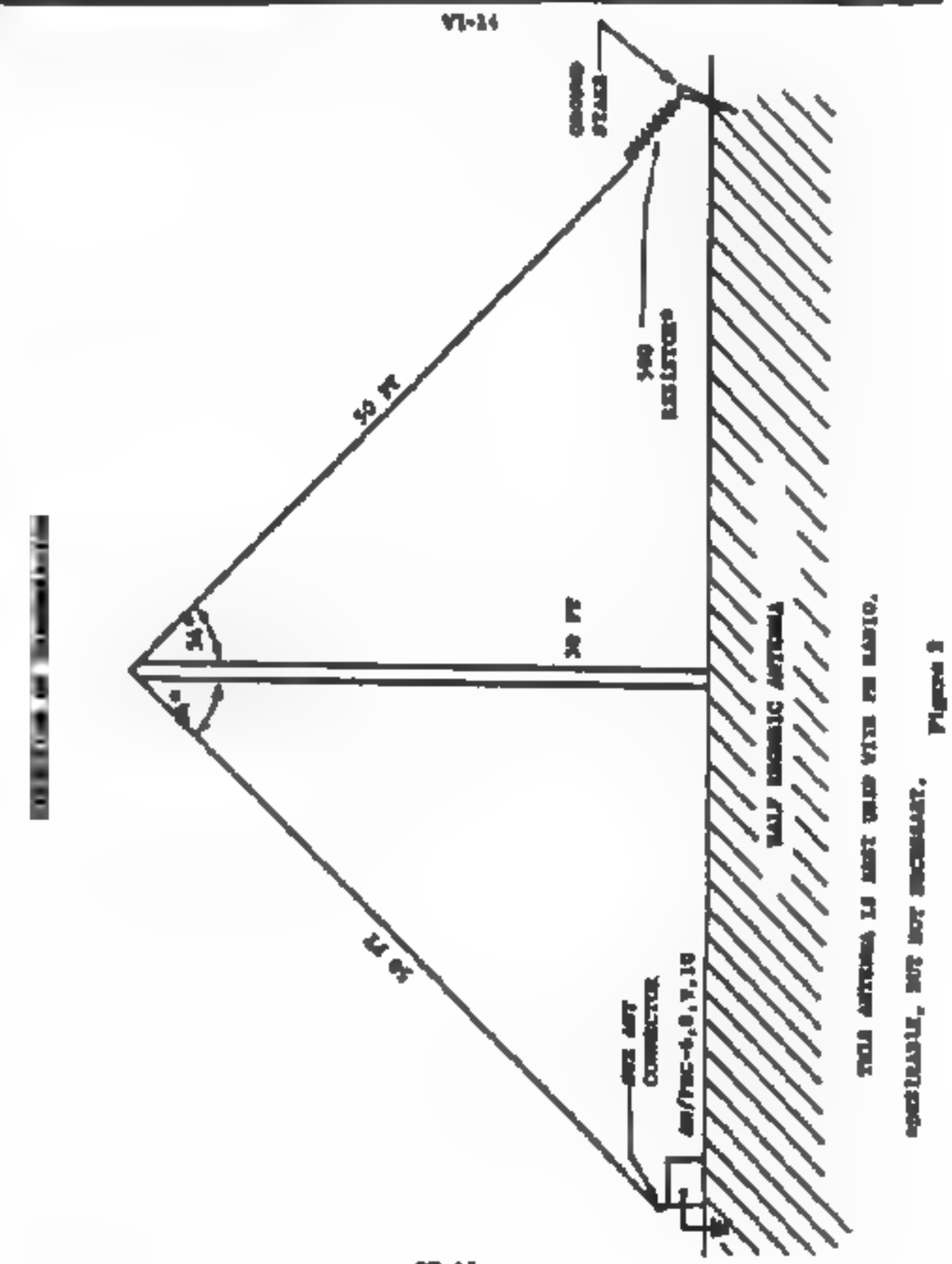

Figure 2

VI-15

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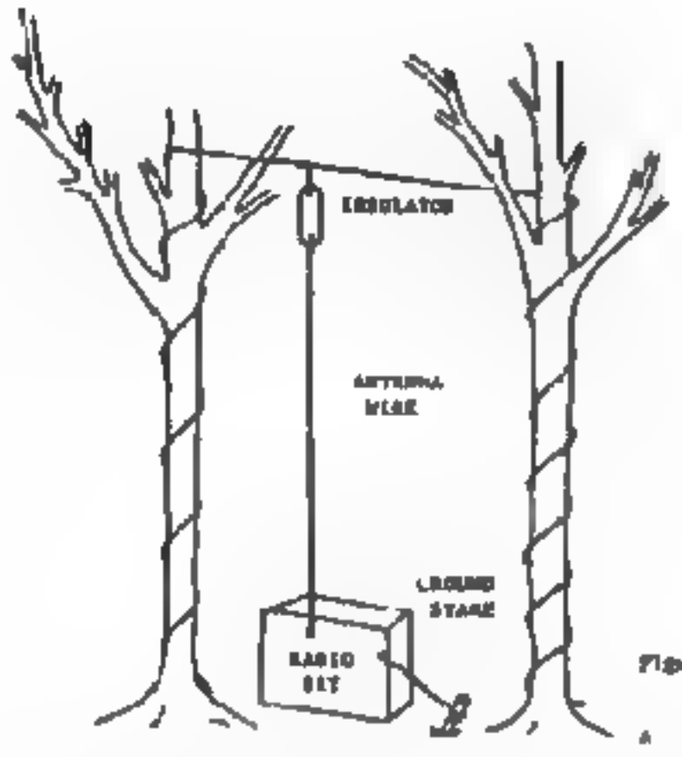
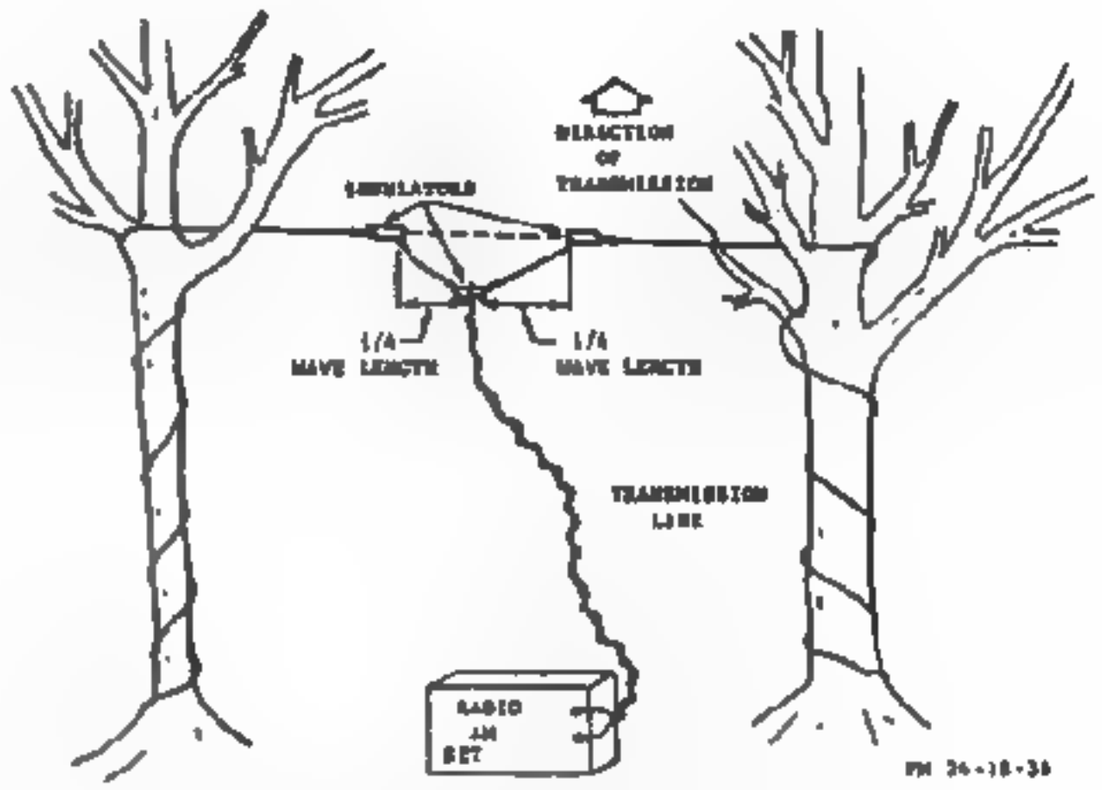


Figure 4

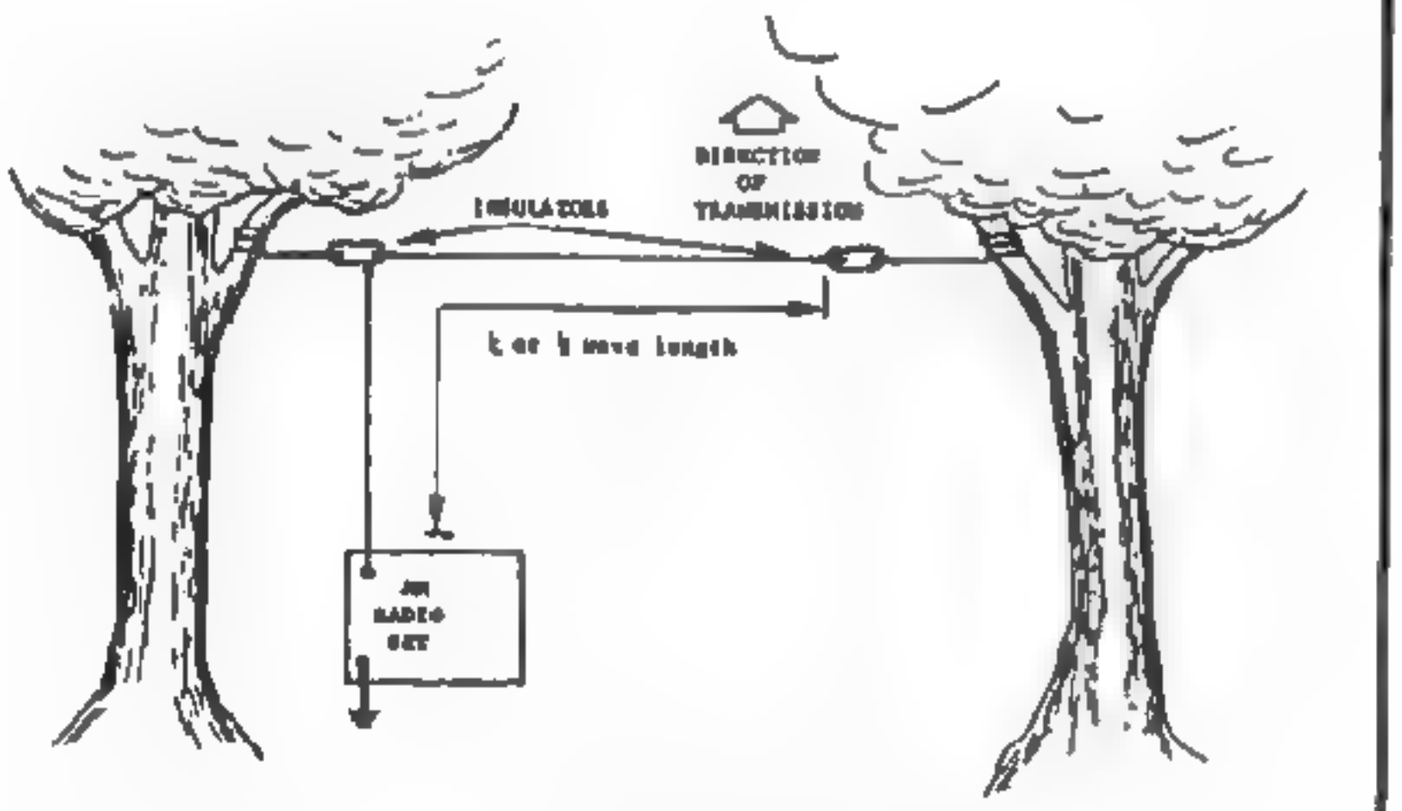
THESE ANTENNAS CAN BE USED WITH FM OR AM RADIO'S. THEY ARE OMNI-DIRECTIONAL. BUT DO NOT HAVE AS MUCH GAIN AS A "LONGER TYPE" ANTENNA. BEST RESULTS ARE GAINED IF WIRE BETWEEN INSULATOR AND RADIO CONNECTION IS CUT TO APPROPRIATE WAVE LENGTH.



IMPROVISED CENTER-FED HALF-WAVE ANTENNA

THIS ANTENNA IS BEST UTILIZED WITH AM RADIO. DIRECTION OF TRANSMISSION IS AT RIGHT ANGLES FROM THE DIRECTION OF THE WIRE.

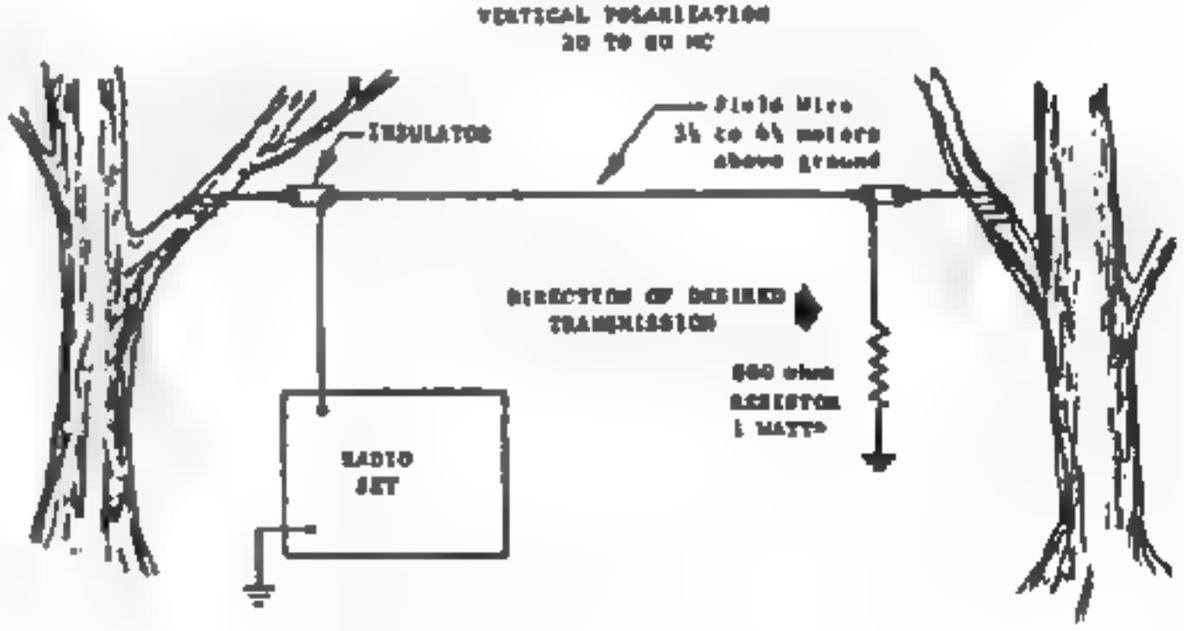
Figure 5



INVERTED "L" ANTENNA (END FED)

THIS ANTENNA IS BEST UTILIZED WITH AM RADIO. DIRECTION OF TRANSMISSION IS AT RIGHT ANGLES FROM THE DIRECTION OF THE WIRE.

Figure 6

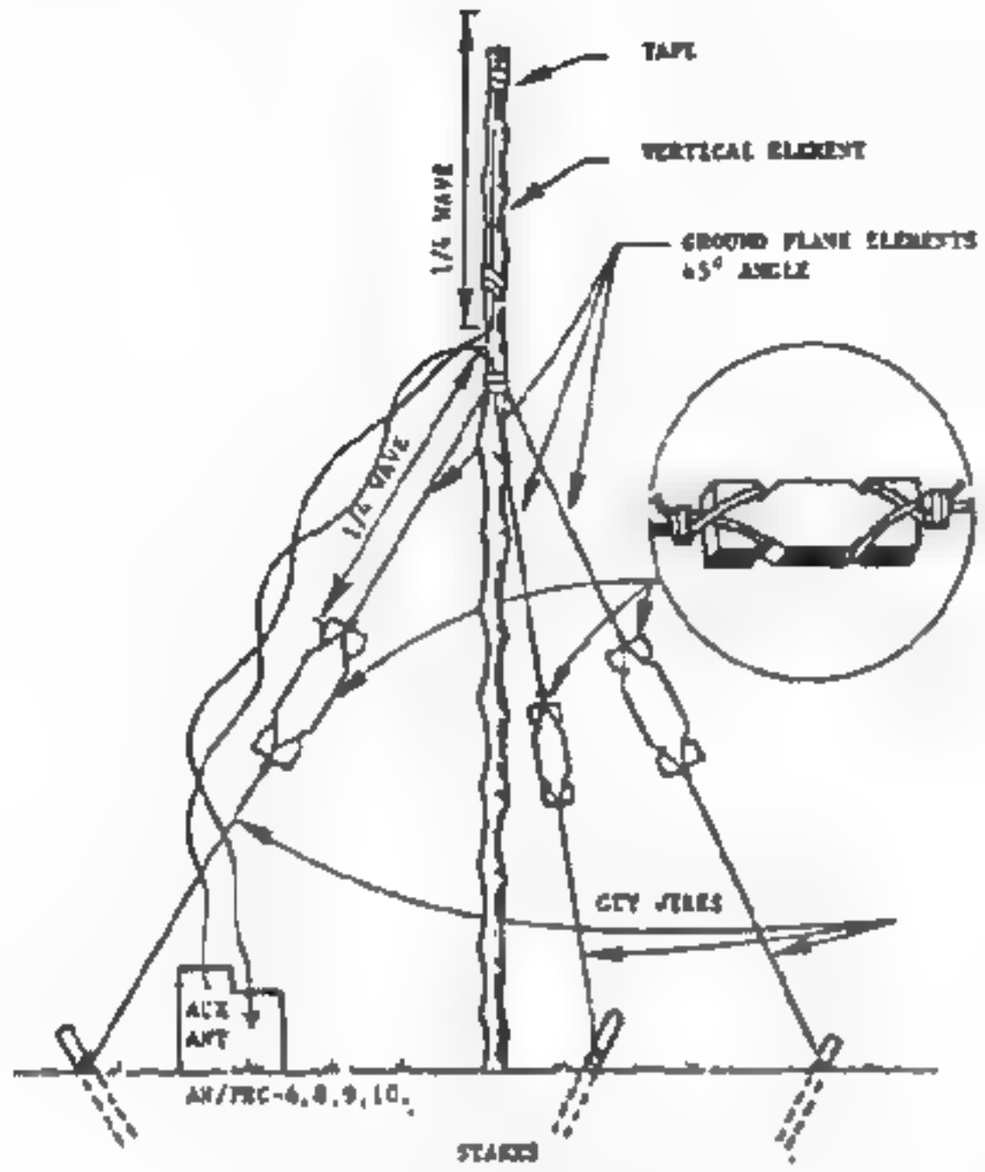


WAVE ANTENNA

THIS ANTENNA IS BEST USED WITH FM RADIO. LENGTH OF WIRE SHOULD BE 30 METERS.

*RESISTANCE NOT NOT NECESSARY.

Figure 7



FIELD EXPEDIENT JUNGLE ANTENNA

THIS ANTENNA NORMALLY USED WITH FM RADIO SETS. IT IS OMNI-DIRECTIONAL. BEST USED FOR NET CONTROL STATIONS.

Figure 7

VI-20

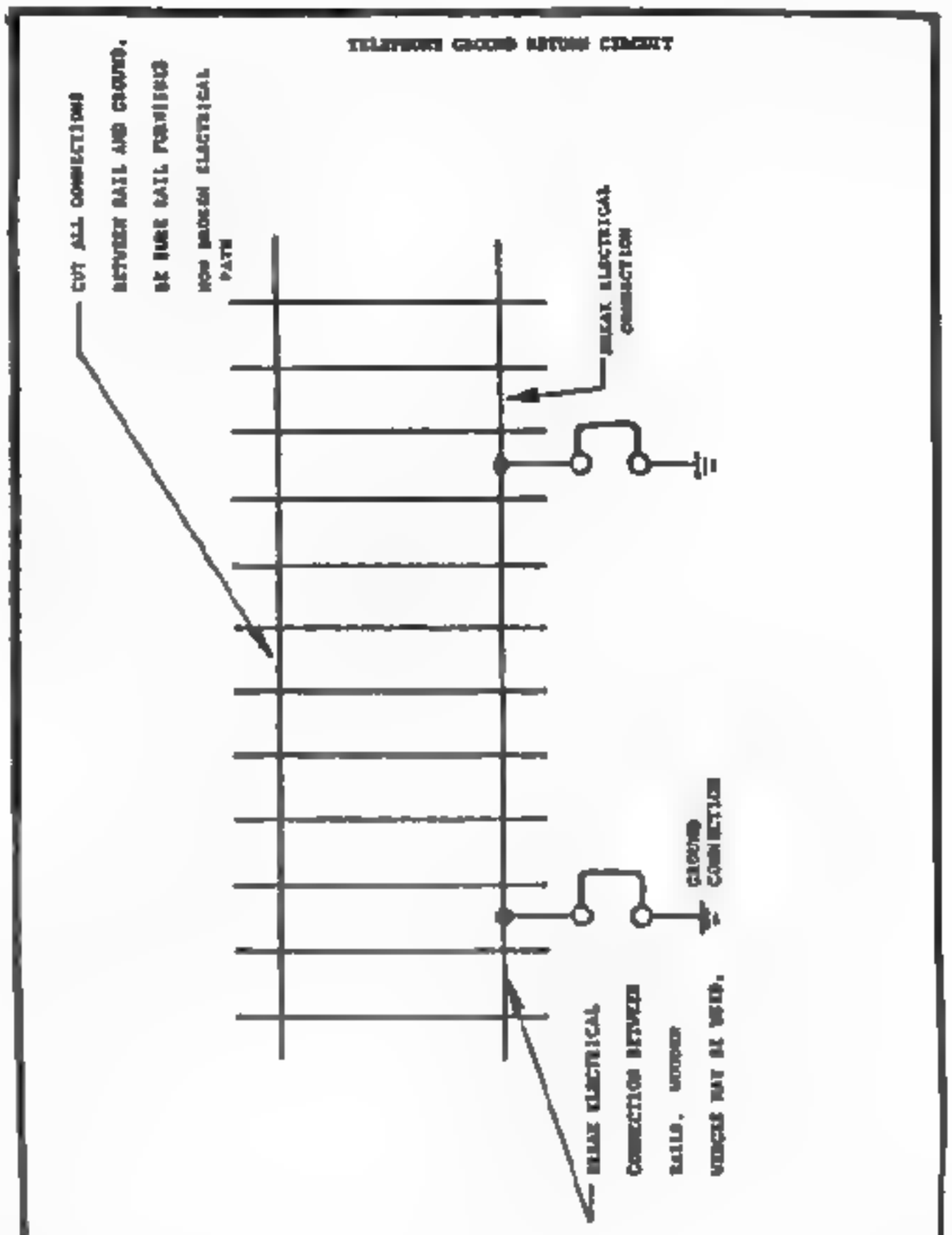


Figure 8

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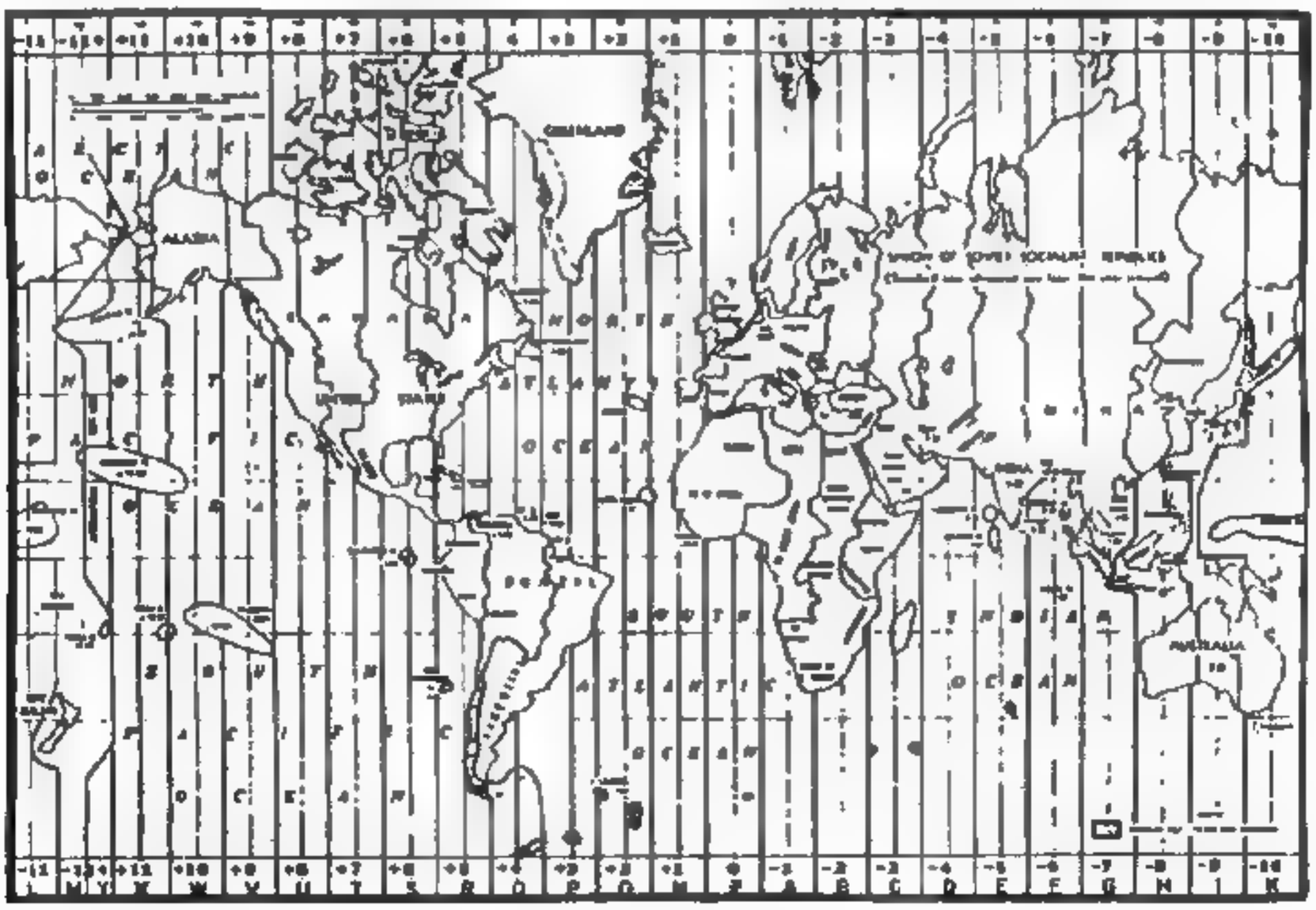

Figure 9 World Time Zone Map

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CHAPTER 7
FIRST AID

TABLE NR. 1 FIRST AID TREATMENT

AILMENT	SYMPTOMS	TREATMENT
Shock	Pale face Cold clammy skin Rapid weak pulse Shallow breathing	Lay patient on back. Lower head, elevate feet. Loosen clothing, keep warm. Feed hot liquids if conscious.
Wound		Expose wound. Control bleeding Apply sterile dressing. Treat for shock.
Fracture	Pain and tenderness Partial or complete loss of motion Deformity Swelling Discoloration	Handle with care, splint before moving. Support the limb on either side until splint is applied. Splints must be long enough to reach beyond joints above and below fracture and must be tied twice above and below break to immobilize limb. Pad all splints Treat for shock.
Burn	First degree: Skin red No blister Second degree: Skin blistered	Carefully remove or cut clothing away from burned area Don't open blisters. Cover area with sterile dressing

VII-1

TABLE NR. 1 FIRST AID TREATMENT CONTINUED

AILMENT	SYMPTOMS	TREATMENT
Burn (continued)	Third degree Skin destroyed and charred	Keep burned areas apart by separate bandages. Treat for shock
Sunstroke (direct exposure to sun)	Flushed face Dry skin Strong rapid pulse Spots before eyes Headache High temperature	Remove from sun Take off all clothing. Elevate head and shoulders Apply cool compresses or bathe patient in cool water Give patient cool salt water.
Heat Exhaustion	Dizziness Nausea Pale face Cramps Cold clammy skin Weak pulse	Move patient to shade. Treat as for shock Give cool salt water
Frostbite	Numbness Waxy colorless tissue Stinging pain at onset	Do not rub, bend or expose to extreme heat or further cold. Warm area to body temperature by holding close to warm body or exposing to warmth no higher than 95 degrees.
Snake Bite	Bites from poisonous snakes will cause swelling in about 45 min.	Treat ALL snake bites as poisonous.

VII-2

1. Snake Bite.

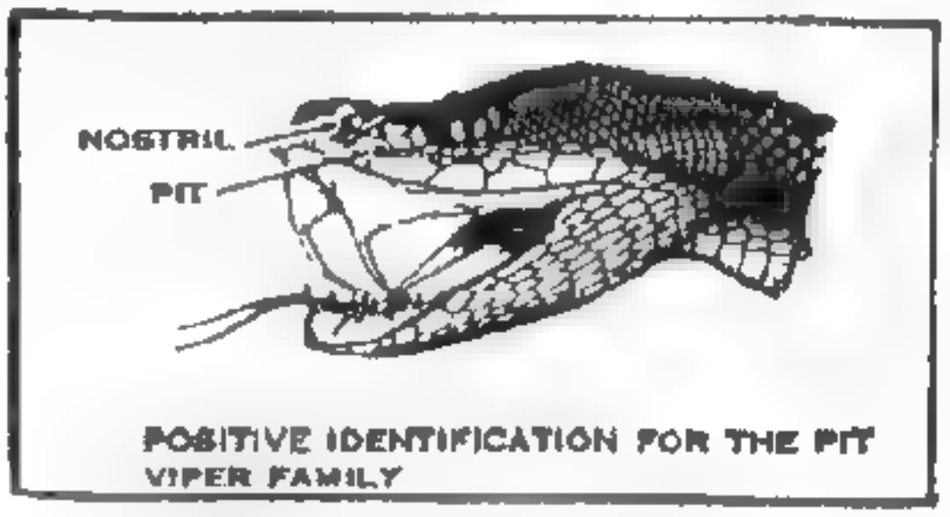
a. Apply a tourniquet 1/4 inch above the bite. Don't put it on too tightly. The object is to retard the flow of blood returning to the heart; not to cut off circulation altogether. Make sure there is a pulse below where the tourniquet is applied. DO NOT CUT. Leave this for the medical officer or medic. As swelling progresses up the limb, move the tourniquet, keeping it 2/3 inches ahead of the swelling.

b. If the victim stops breathing, begin mouth-to-mouth resuscitation and continue till a medical officer arrives.

c. Send for medical help ASAP. If no one else is available to go, and the patient is conscious and alert, it will be necessary to leave him alone while you go. Before leaving, give him instructions to remain still and to move the tourniquet as required.

d. Keep the patient QUIET. If it is impossible to bring help to him then carry him to aid.

e. Make tourniquet just tight enough to retard flow of lymph.



POSITIVE IDENTIFICATION FOR THE PIT VIPER FAMILY

Figure 1 Identifying a pit viper

VII-3

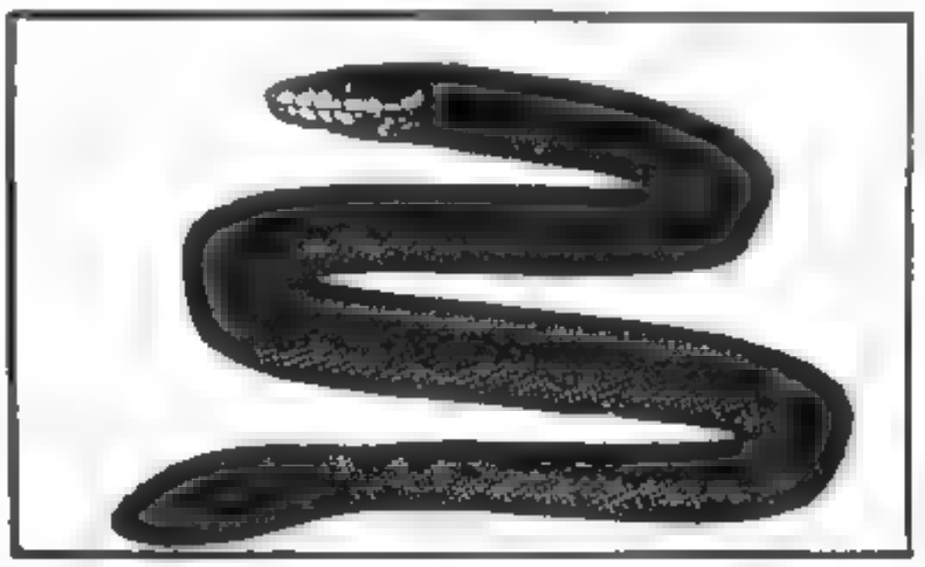
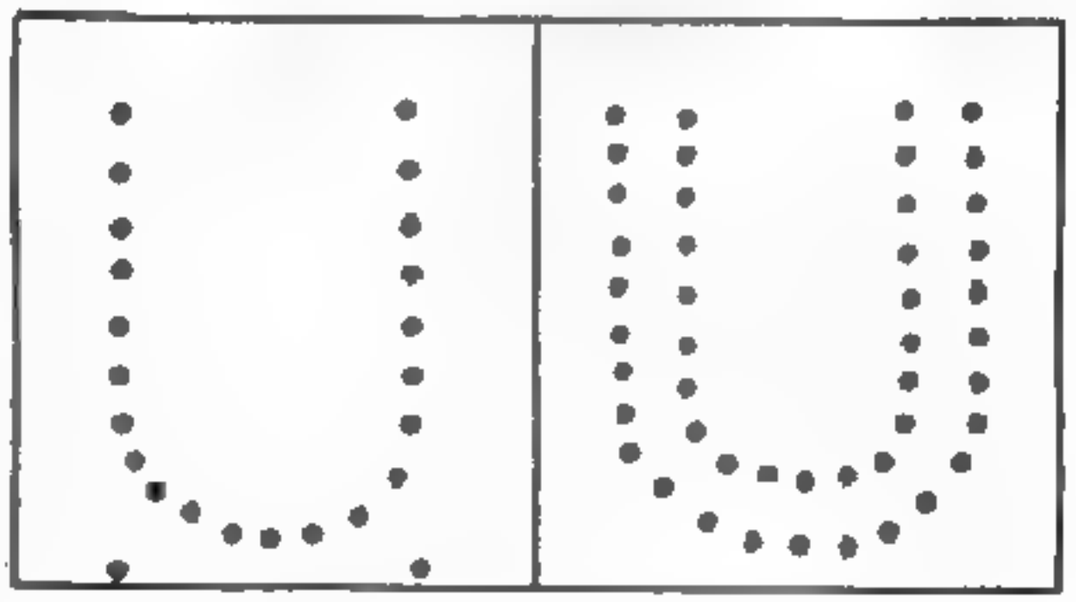


Figure 2 Sea Snake



Teeth marks of poisonous snake (note fang marks)

Teeth marks of non-poisonous snakes (note two rows)

Figure 3

VII-4

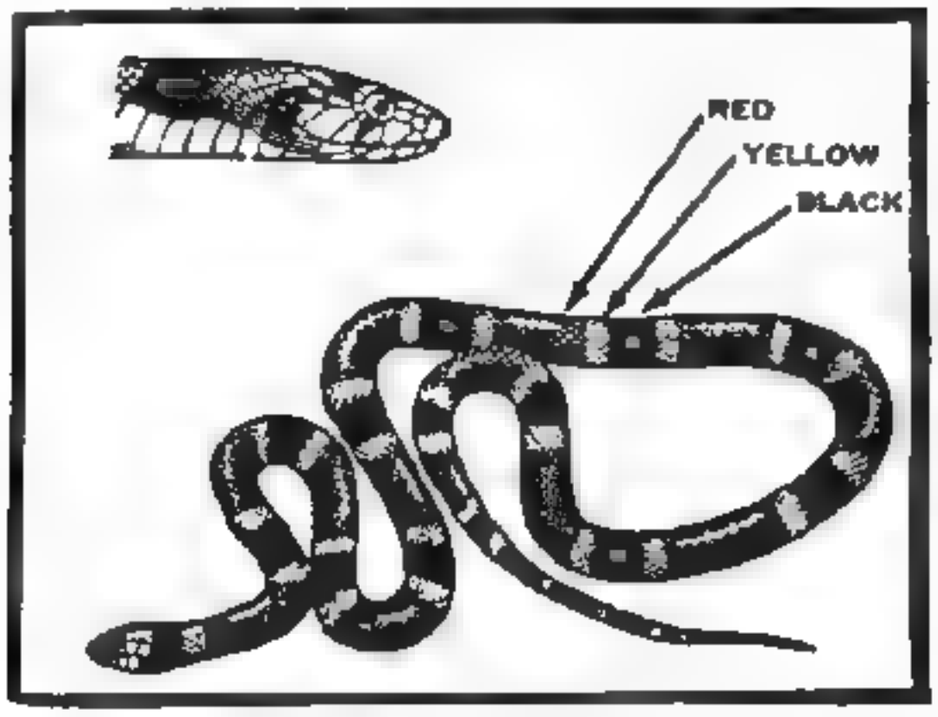


Figure 4 Coral Snake

II. FIRST AID PRINCIPLES:

a. Stop bleeding.

b. Protect the wound.

c. Prevent or treat for shock.

d. Splint fractures.

III. CONTROL OF BLEEDING:

a. Elevate injured member if not fractured.

b. Apply pressure bandage.

c. Use pressure points if blood is gushing (wherever strong pulse is felt. (See figure on pressure points.)

VII-5

d. Use tourniquet only as last resort.

IV. PRESSURE POINTS:

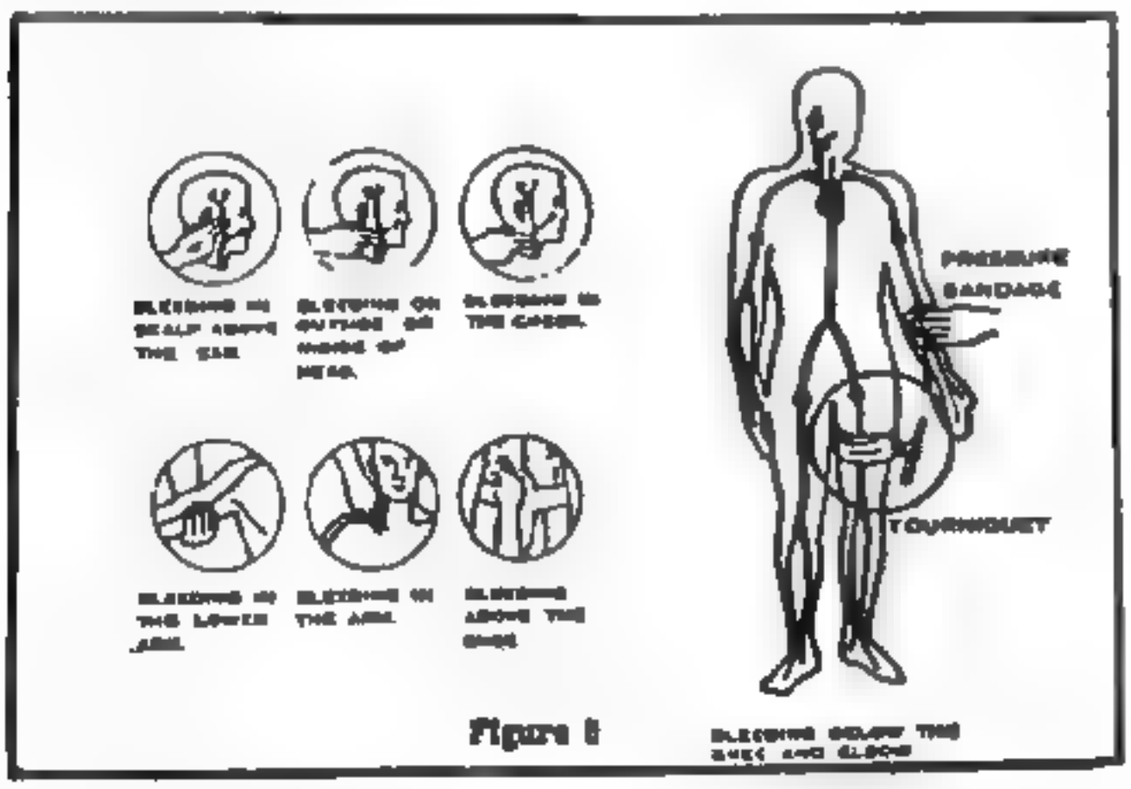


Figure 5

V. TYPES OF BLEEDING:

a. Arterial — spurting

b. Venous — flowing.

c. Capillary — oozing.

VI. ARTIFICIAL RESPIRATION - BACK-PRESSURE ARM-LIFT:

a. Place your hands on the flat of the victims back so that the palms lie just below an imaginary line running between the arm pits. With tips of your thumbs just touching, spread you fingers downward and outward.

b. Rock forward, with elbows straight until your arms are almost upright and let the weight of the upper part of your body press slowly, steadily and evenly downward on your hands on the victim's back.

c. Release the pressure by removing the hands from the back without a push and rock slowly backward on your heels. As you do this, slide your hands onward and grasp the victim's arms near the elbows.

d. Draw the victim's arms upward and toward you with just enough of a lift to feel resistance and tension at the victim's shoulders. Do not bend your elbows. Then lower his arms to the ground.

e. Continue this action until normal breathing is resumed by victim.

VII. ARTIFICIAL RESPIRATION - MOUTH-TO-MOUTH:

Figure 6

VII-7

ARTIFICIAL RESPIRATION - MOUTH-TO-MOUTH (CONTINUED)

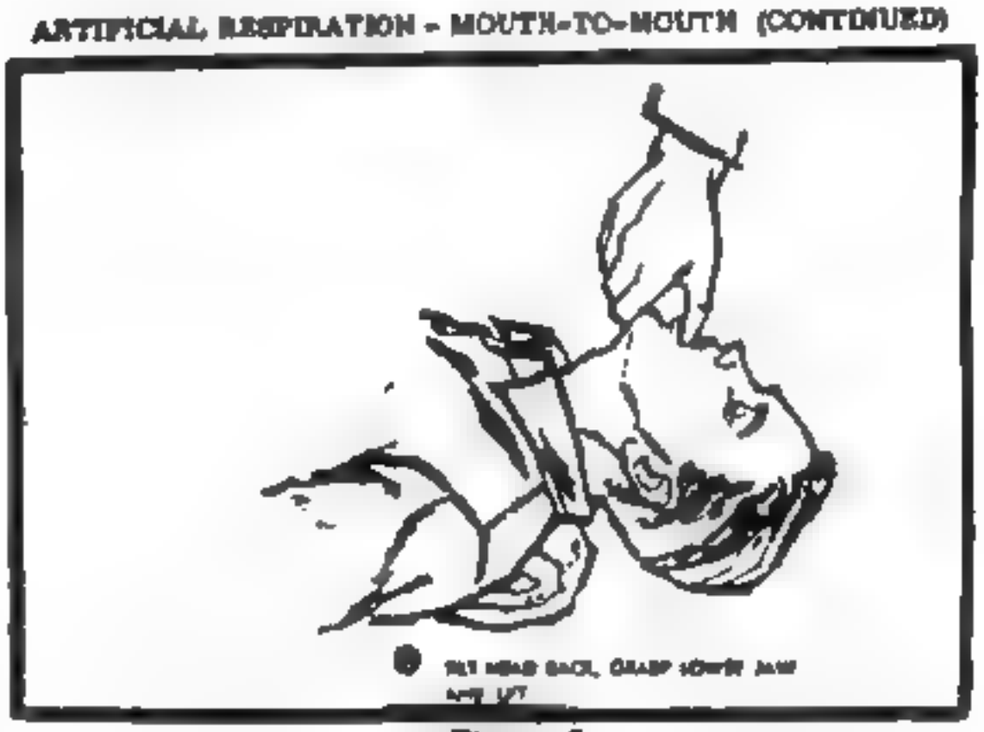


Figure 7

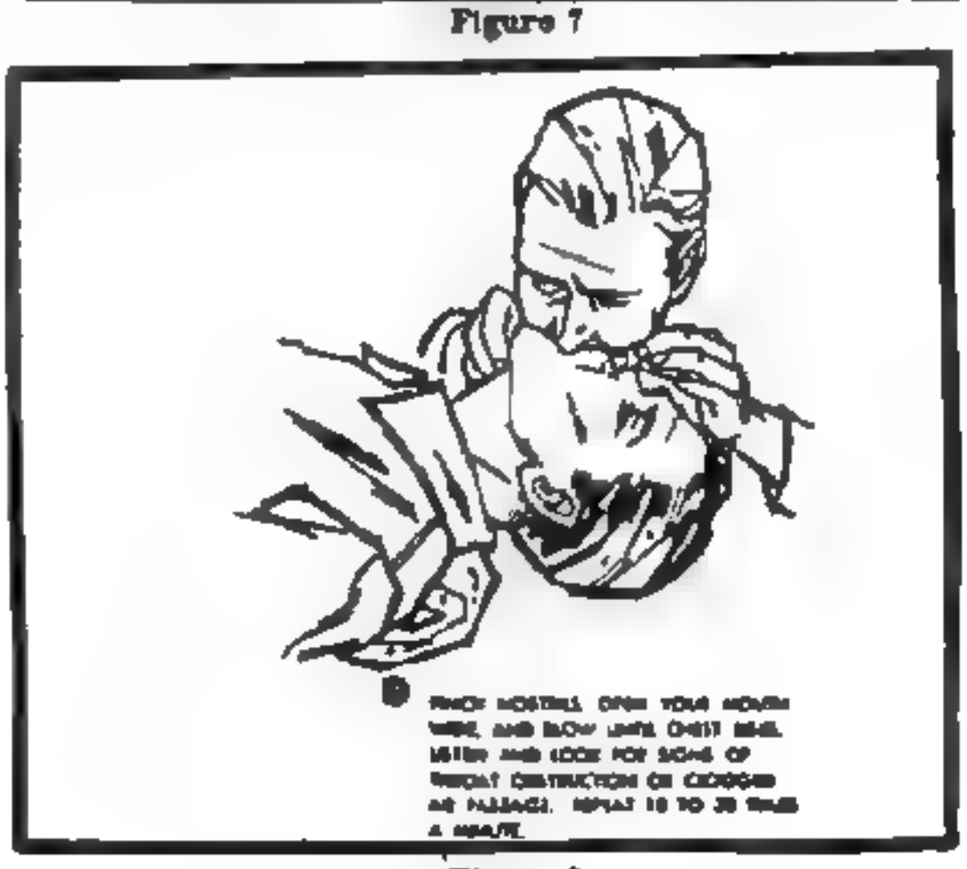


Figure 8

CHAPTER 8
SURVIVAL

HOT-WET SURVIVAL INFORMATION

1. Be Alert
2. Be Wary of Strangers
3. Guide on Trails to Friendly Villages
4. Follow or Float on Waterways to Sea Coast
5. Food Grows in Fields Near Villages
6. Conceal All Evidence of Your Being in an Area
7. A Few Feet into Dense Jungle Will Hide You
8. Insect Repellent Applied to Fiber Makes Good Tinder
9. Boil or Treat All Water Used for Drinking or Washing

VIII-1

L. EVASION.

a. First, get as far away as possible. Sometimes this may mean several miles; at other times, just a few yards. Plan your escape, do not run blindly. Use your head -- there is no substitute for common sense. As soon as possible, sit down, think out your problem, recall what you learned in training.

b. Pinpoint your location as accurately as possible, using your compass, sun, map, known landmarks, etc. If your compass is broken or lost, remember that when facing the sunrise, North is to your left. The following methods can be used for determining direction.

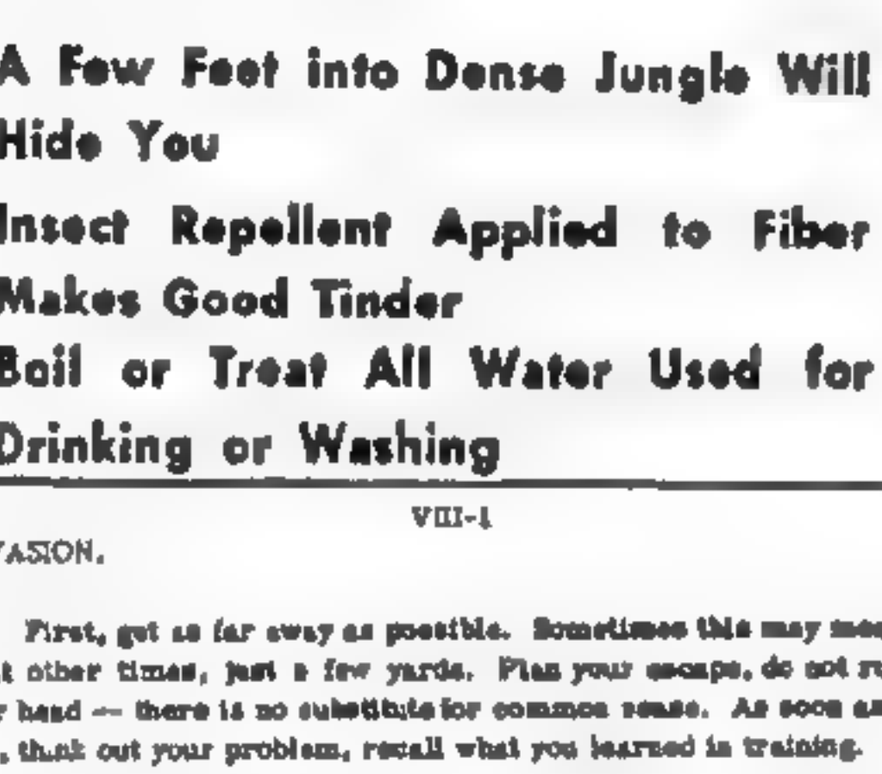


Figure 1. Southern Cross.

c. Using the Southern Cross: In the Southern Hemisphere you can find south by locating the Southern Cross. Compare this group of stars to a kite. If you can figure the length of the kite from tip to tail and extend an imaginary line from the tip of the tail four and one-half times the length of the kite, you can determine the approximate direction of south.

VIII-2

d. Using a watch to find north:

(1) General. The sun always appears to be south of the north temperate zone and north of the south temperate zone. A timepiece can be used to determine the direction of true north utilizing this fact, while compensating for the eastward to westward movement of the sun.

(2) North temperate zone.

a. Hold timepiece so that hour hand points at sun.

b. Mentally draw an angle with its vertex at the center of the timepiece, one line passing through the number 12 and the other line along the hour hand.

c. Cut this angle in half and note its imaginary projections on the ground.

d. This imaginary line, bisecting the angle mentally drawn, points south, its reverse direction is north.

(3) South temperate zone.

a. Hold timepiece so the figure 12 points at the sun.

b. Mentally draw an angle with its center at the center of the timepiece and its sides passing through the figure 12 and along the hour hand.

c. Bisector now points north.

VIII-3

e. The diagrams below, graphically illustrate the methods of finding north

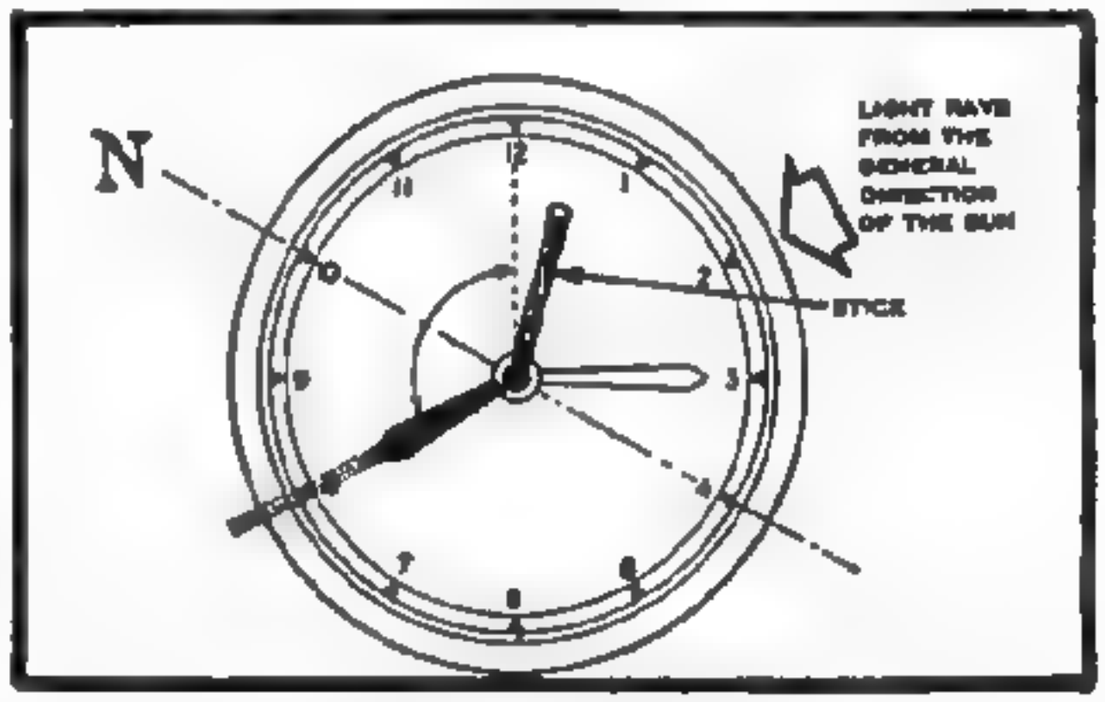


Figure 2. Finding north in the north temperate zone.

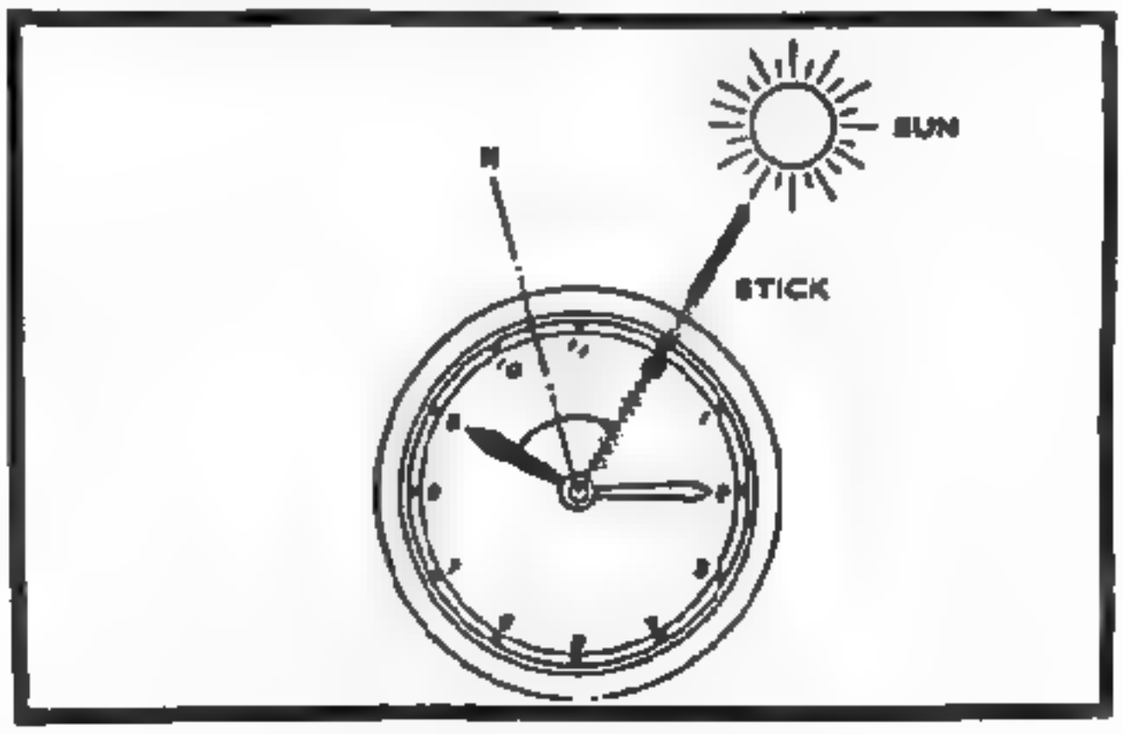


Figure 3. Finding north in the south temperate zone.

VIII-4

f. Shadow tip method for finding direction: Drive a stake so that at least three feet of it is above the ground. Mark the tip of the shadow it casts. Wait for a while--10 minutes is long enough--and mark the spot where the tip of the shadow is then resting. A line drawn between the two marks will always point north.

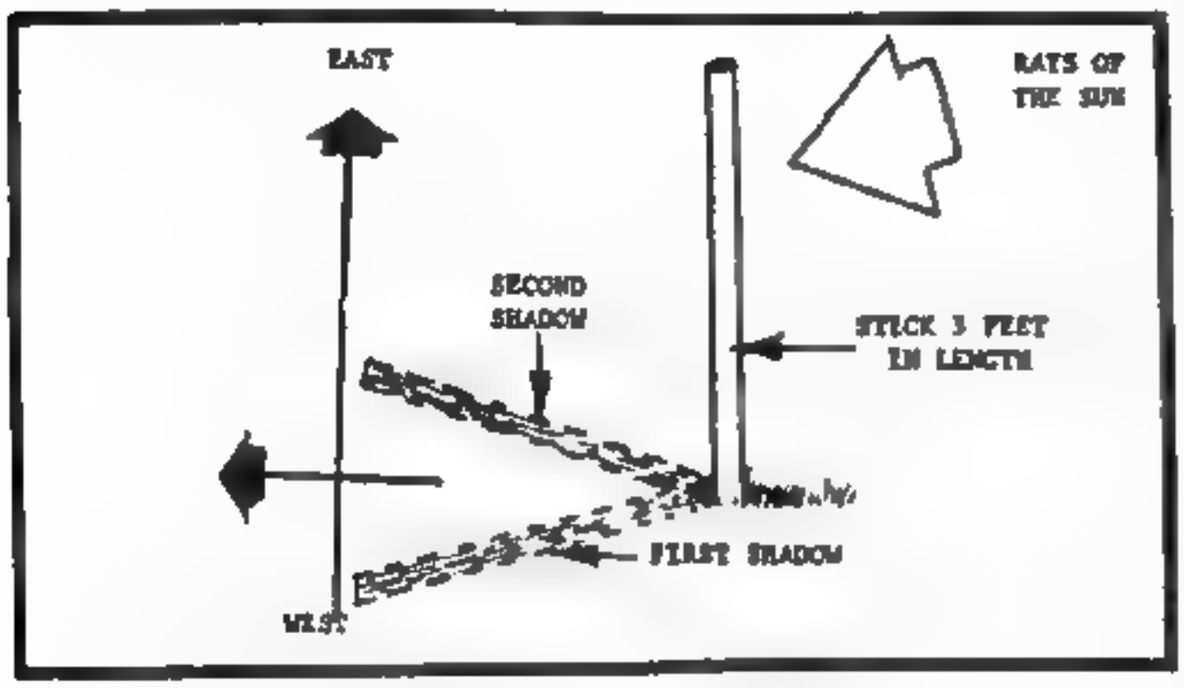


Figure 4. Shadow Tip Method.

*In north temperate zone, this direction will be true north.
In south temperate zone, this direction will be south.

VIII - 7A

g. Study the map. Determine the slope of the land to guide on. Notice all large waterways. People usually live and travel on the waterways.

h. Determine the direction in which you wish to go, move in one direction, but not necessarily in a straight line. Pick a linear objective, not a point objective, as it is easier to locate. Avoid obstacles -- don't fight them. Take advantage of natural cover and concealment. Blundering through jungle and wooded areas leads to bruises, scratches, and quick exhaustion.

i. Check bearings often. Roads and trails can be used to guide on, but never travel on them. Stay alert. Natives remain on trails by preference. A few feet from the trail you are usually quite safe. Conceal yourself upon the approach of any other person until he passes or until you determine whether or not he is friendly.

j. The easiest traveling is often on the crests of ridges. Remember, however, that crests are more exposed than hillsides, and because of ease of travel, they are apt to be traveled more frequently than other areas.

k. Rivers or streams can make good roads but remember that the majority of native villages and encampments are on water. Rafts attract attention. Floating on or close to a log or drifting bank may be the simplest way to travel. Keep to the middle of the stream. If using a native boat, sink it during periods when not in use.

l. When close to known enemy locations, move right after sunset or just before sunrise when there is sufficient light to enable you to avoid enemy installations, mine fields, sentries, etc., but dark enough to prevent recognition by the enemy. Arrange your clothing, weapons, etc., to present a profile as similar as possible to the natives of the area.

m. Be quiet, noise carries far and natives are alert to any strange noise. Bury your refuse. If the enemy finds sign of your presence, it may lead to your [illegible]

n. Do not sleep near your fire or your water supply. Get far enough away to be [illegible].

o. If lost in grass that is so tall that you cannot see over it, as a last resort cut down enough to give you some freedom of movement and, using your machete or any other tool, dig a hole to crawl into and set fire to the grass. Take every precaution not to get burned by fire or asphyxiated by smoke.

VIII-8

p. The jungle provides many hiding places. You may have to use them. Bamboo thickets are excellent. Because of the nature of bamboo, you cannot be approached without being alerted by the noise of dry bamboo.

q. When approaching camp, use extra precaution, for the camp is probably being watched.

r. At all times when hiding or remaining in one location for a period of time, be sure to plan more than one exit.

II. SURVIVAL.

a. Get to known friendly village as soon as possible. Avoid all others except as a last resort. It is difficult for a person unfamiliar with the jungle to live in it without native assistance.

b. Before entering any strange village, whether it is friendly or not, conceal your weapons. If it is an enemy village, weapons will be taken from you. If it is a friendly village, you can always go back and get them from where they [illegible]

c. Many of the jungle diseases are insect borne. Use insect repellent freely, if available.

d. Take time to repair your clothes. It helps to prevent insect bites and further tearing of clothes.

e. Examine your surroundings carefully. Many of your needs are there. Thorns broken from bamboo or trees can be used for needles. Strips of vines can be made into thread. If you need rope, vines will do. Your food and shelter, in fact your life, may depend on your ability to make use of things that are all around you.

f. Be careful. Do not use trees and vines to pull yourself up hills as thorns, ants, scorpions, etc., will be encountered and make sores that may become infected. Use a walking stick to push aside vines and bushes.

g. Poisonous reptiles and large mammals of the jungle will cause few problems. Given a chance, they will avoid you.

h. If a survival kit is available most articles are self-explanatory. Some have multiple uses. The waterproof adhesive tape can be used for temporary repairs to clothing and mosquito nets as well as covering body wounds. Fish line can be used for snares. Three fish hooks, their shafts tied together with their

VIII-9

hooks pointing out, can be used on the fish line to snare fish, crabs, etc. Head nets can be used as fish nets and snares. A fish hook fastened to a length of line, baited with fish or meat and left on the sea shore or in a field may be used to catch birds.

III. WHEN REQUESTING NATIVE ASSISTANCE:

a. Show yourself and let the natives approach you.

b. Deal with recognized headmen.

c. Do not approach groups.

d. Do not display weapons.

e. Do not risk being discovered by children.

f. Treat natives well. There is much you can learn from them.

g. Respect local customs and manners.

h. Learn all you can about woodcraft.

i. Take their advice on local hazards.

j. Never approach a woman.

IV. SHELTER.

a. Pick a high spot when making camp. Avoid dry river beds, dead trees,

and ant nests. Avoid bat caves, droppings may cause rabies.

b. Do not sleep on the groundif you can avoid it. Use your hammock if you have one, or make one of poncho or the multi-purpose net. If this is not possible, build a platform of bamboo, small branches, etc. It will assist in avoiding insects, reptiles, etc.

VIII-7

c. Types of jungle shelters:

(1) Simple parachute shelter made by draping a parachute over a rope or vine stretched between two trees.

(2) Thatch shelter (see figure 5) made by covering an A-type framework with a good thickness of palm or other wood leaves, pieces of bark, or mats of grass. Slant the thatch shingle fashion from the bottom upward. This type of shelter is considered ideal since it can be made completely waterproof. After you finish your shelter, dig a small drainage ditch just outside its lines and leading downhill; it will keep the floor dry.

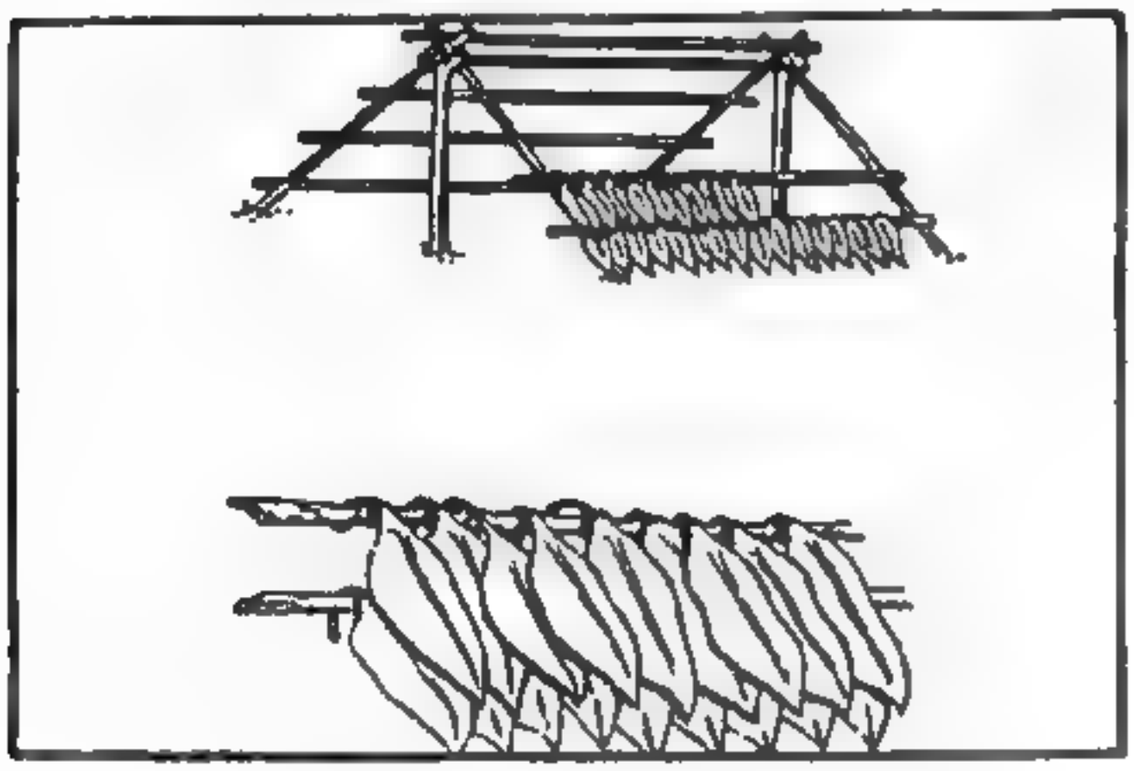


Figure 5. A-type framework.

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(3) Beds. Don't sleep on the ground; make yourself a bed of bamboo or small branches covered with palm leaves (see figure 6). A parachute hammock may serve the purpose. You can make a crude cover from tree branches or ferns; even the bark from a dead tree is better than nothing.

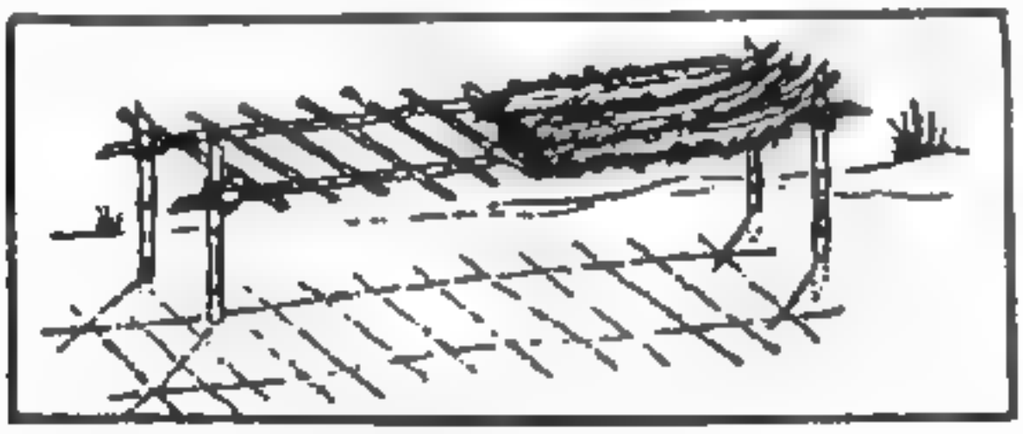

Figure 6. Bamboo bed.

V. WATER.

a. Water is more important than food. If you have no water, do not eat. Check all drinking water for leeches and other small aquatic animals.

b. Indian wells. In dry areas, water can usually be found by digging a hole two or three feet deep in the bottom of dried up streams and river beds. When water has been obtained, camouflage hole.

c. Boiled or untreated water.

(1) Many vines have water in them. The vine should be cut through. When a nick is cut in the vine about three feet above the original cut, a potable liquid will drip out. Do not apply vine to lips. Avoid any vine, plant, or tree with milky juice as many are poisonous. Water can be found at the base of the

VIII-9

leaves of palms; or in sections of dead bamboo (see figure 7). A section of bamboo placed against a tree will collect water during rain. Moisture collects under leaves in the dry season. Rub these with a cloth or other absorbent material, squeeze it out into container.

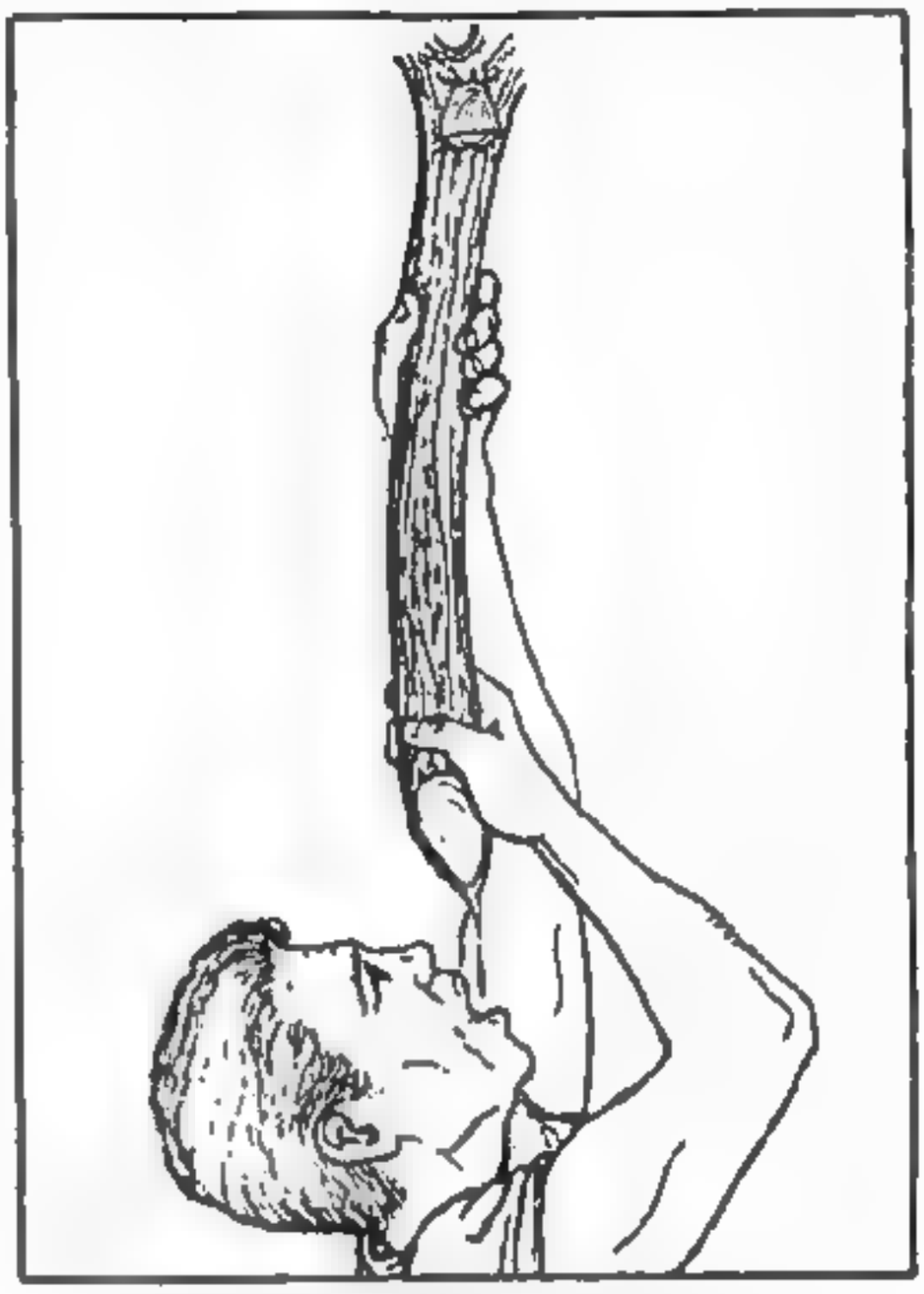

Figure 7. Extracting water from vines.

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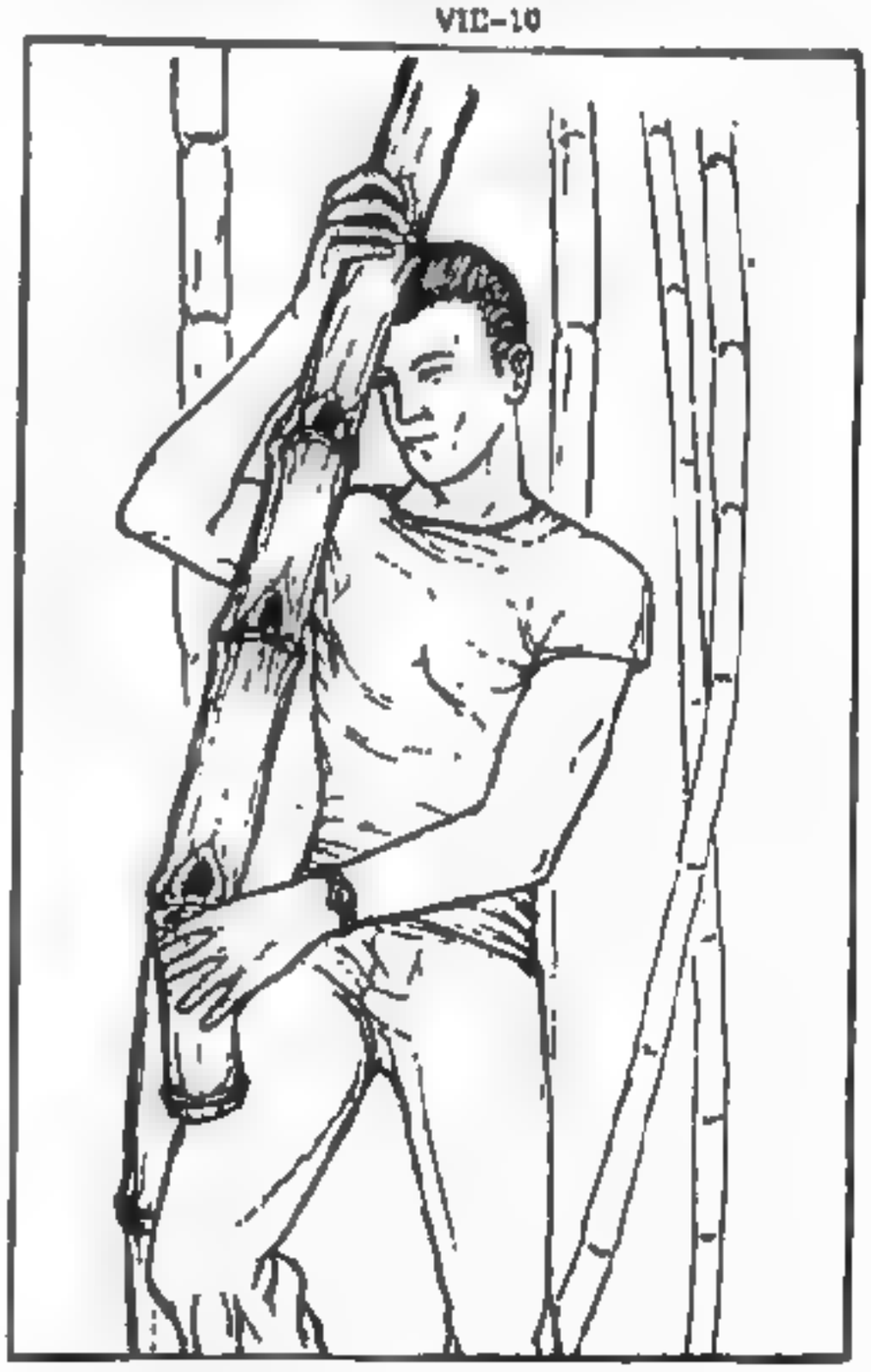


Figure 8. Bamboo joints contain water.

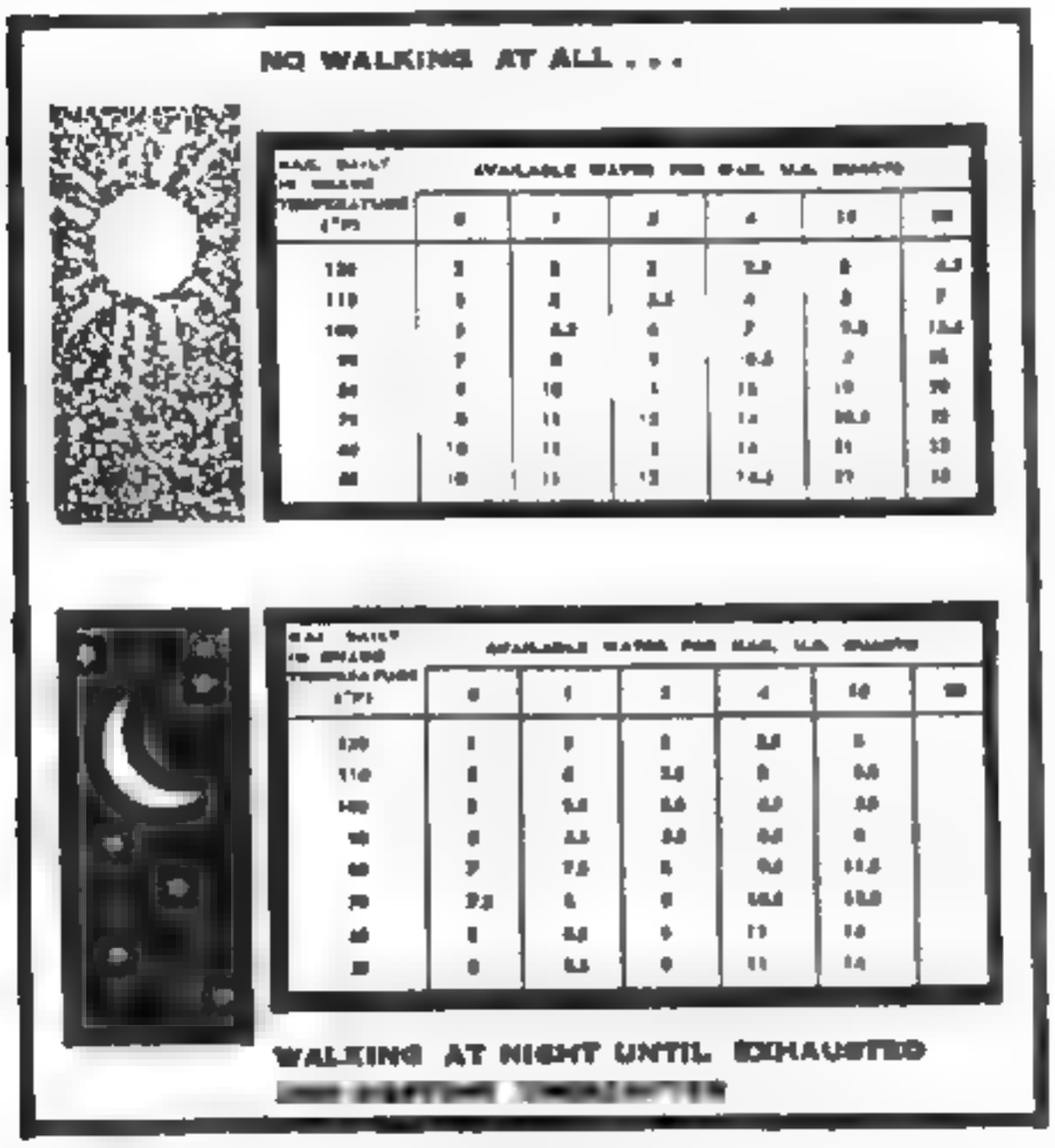
(2) At the sea shore, drinkable but brackish water can be procured by digging a hole ten feet above the high tide line.

(3) If water is scarce, travel during coolest part of day or during night.

VIII-11

Rest during heat of day. By doing this, the water content of the body is con-

TABLE NR. 1 SURVIVAL TIME CHART



NOTE: Columns 1-7 show survival time in days.

VI. FOOD.

a. There is food in the jungle if you know where to find it. Plan one good meal each day but nibble on any food that you may have or can find. Eat strange food in small quantities and wait for a reaction. Avoid all mushrooms. There is little nutritional value in them and much danger.

(1) In villages, eat only food that is hot, if possible. If for fear of offending your host you have to eat native food that is not hot, take a yellow pill to avoid dysentery. All vegetables or fruit procured in a village or handled by natives should be peeled.

(2) Possession of a knife is vital for successful foraging. If you do not have one, a serviceable blade can be made from split bamboo. Split dry bamboo with a stone, break out a piece, sharpen on a stone, fire harden and resharpen. The result will be a crude but effective tool or weapon.

b. Animal food. Grasshoppers, ant eggs, hairless caterpillars, larvae and termites, are good when cooked. Remove heads, skin, and intestines of snakes, rats, mice, frogs, lizards, before cooking. Bats can be caught in caves by flailing the air through which they are flying with a multi-branched stick. Inasmuch as bats are carriers of hydrophobia, do not get bitten.

c. Traps and snares. Indiscriminate placing of traps is a waste of time. Small game such as rabbits, mice, etc., travel on paths through the vegetation. Set traps in or over these trails. A serpentine fence will guide certain birds, like pheasants and some larger animals, to your traps. Cut or collect brush for the fence and build it two feet high or more. Place traps in depth of curve.

VIII-13

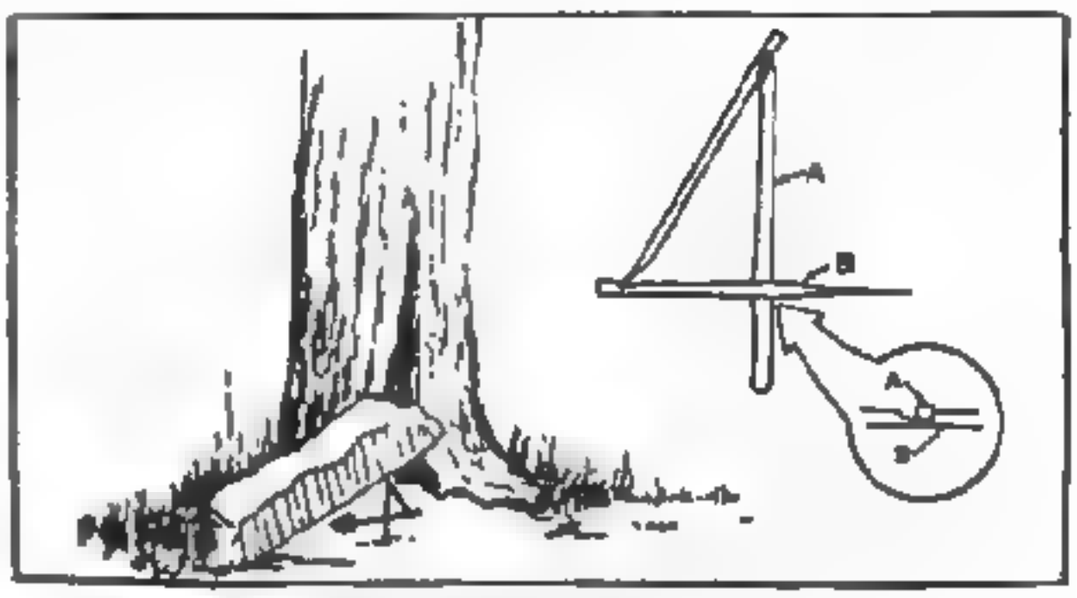


Figure 9. A simple deadfall using a figure 4 trigger.

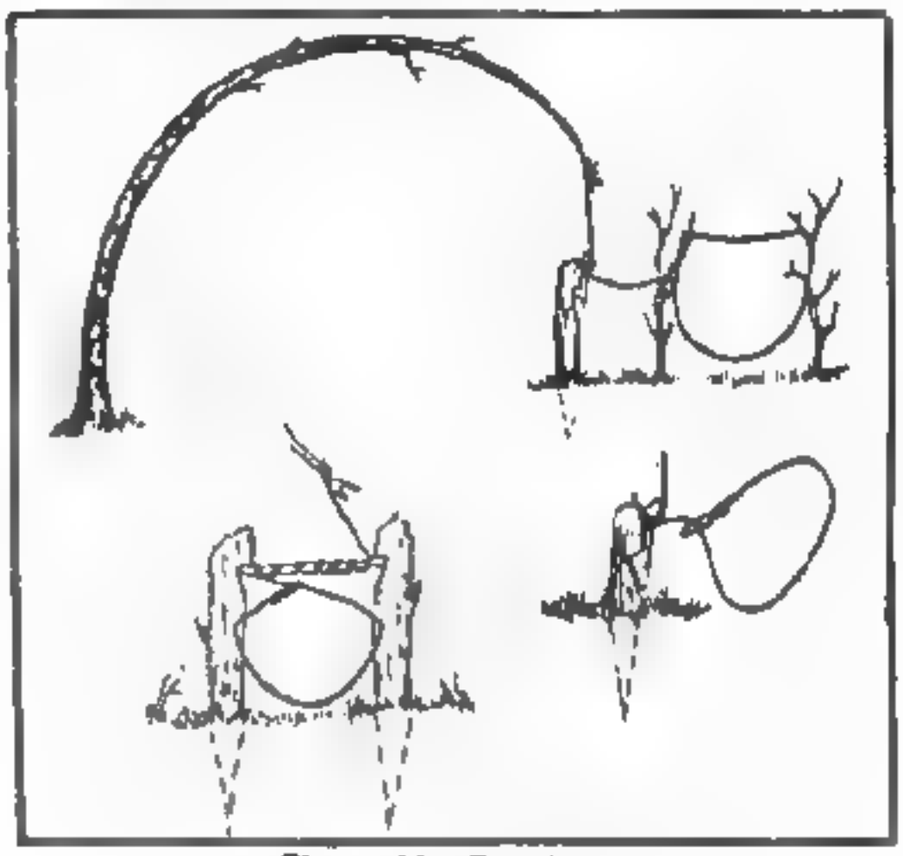


Figure 10. Fixed snares.

VIII-14

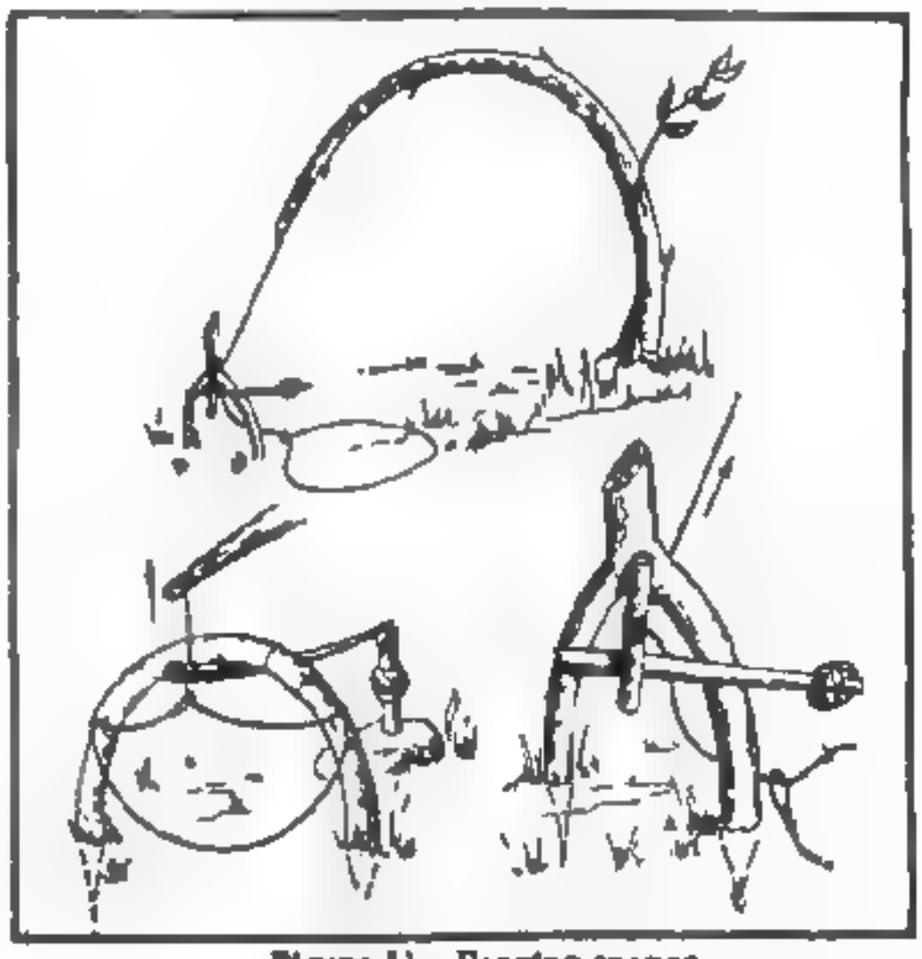


Figure 11. Hanging snares.

VIII-15

d. Fish. There is no rule to determine edible fish. Avoid all strange or oddly shaped fish. Only those mussels, clams, oysters, etc., that are found underwater at low tide are safe. Salt water fish and shell fish can be eaten safely raw. Do not eat the eggs or intestines of any fish. Salt water snails come in all sizes and shapes. All are good to eat. Avoid cone snails and terebra. Some have poisonous stings that can be fatal. Never eat fresh water fish without cooking or when the flesh is soft or the eye sunken for they are undoubtedly diseased.

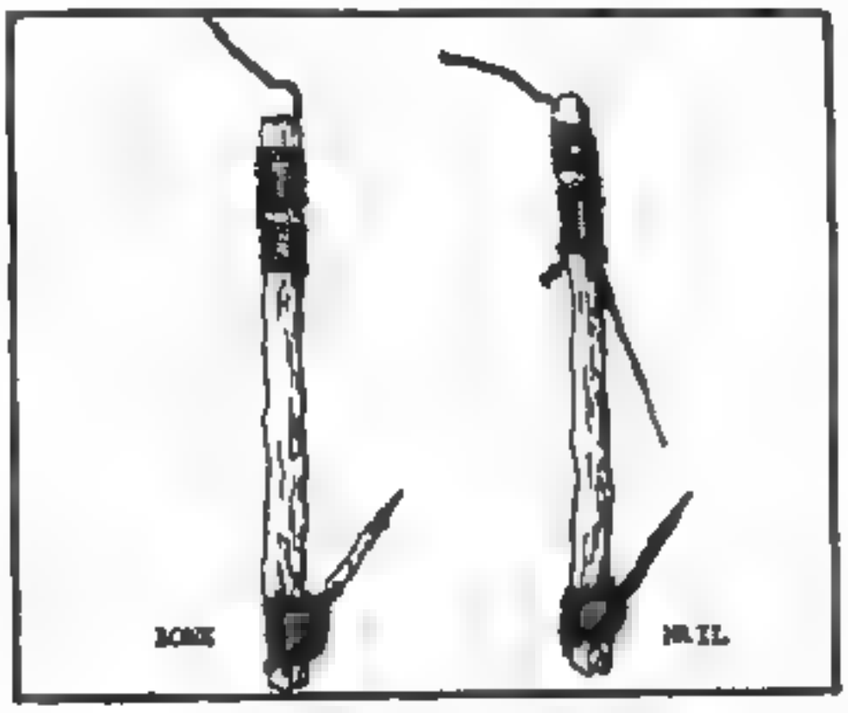


Figure 12. Improvised hooks and lines.

(1) Fish are attracted to light. If the area is safe, use torches at night to attract the fish. A headnet made in a circular form by threading with bamboo or strung on a crotched stick will make a dip net. Fish in ponds or at the edge of the beach can be driven into the shallows by flailing the water with hands or

brush. Clean fish immediately when caught. If you are in a group, work together to drive the fish and to net them. Help each other.

(2) Do not try to preserve meat or fish for any length of time. In the tropics flesh of any kind spoils rapidly unless dried or smoked.

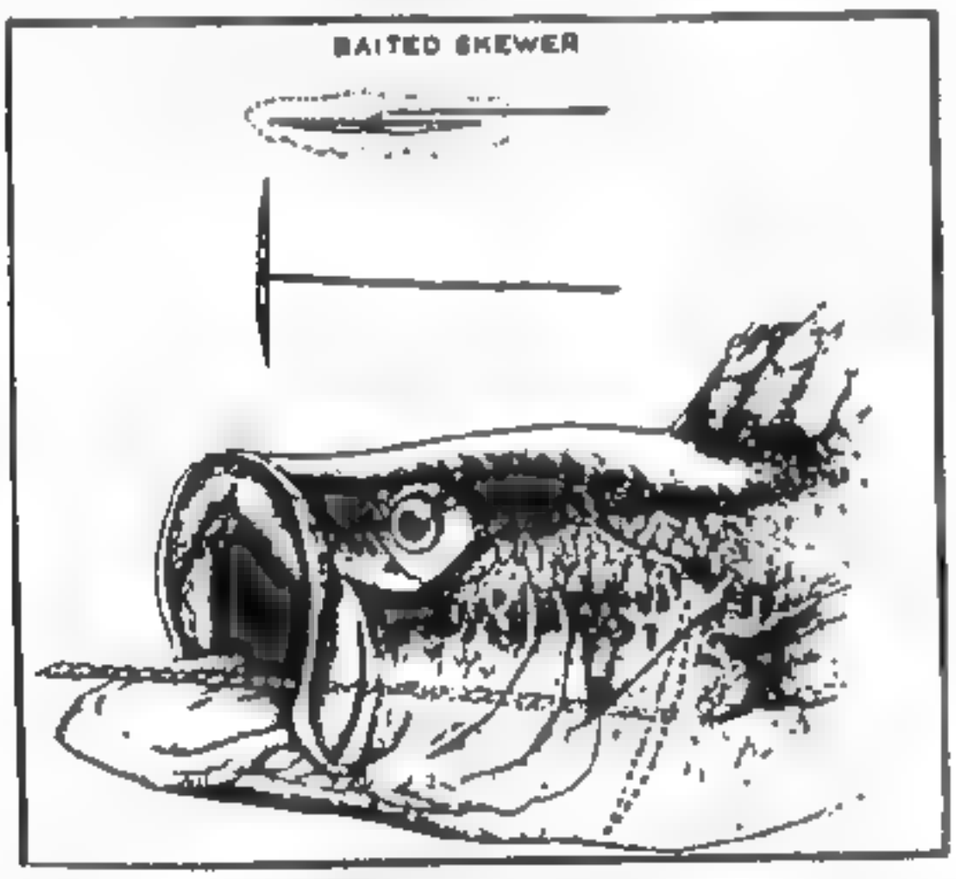


Figure 13. Skewer hook.

(3) Skinning and cleaning. As soon as you catch a fish cut out the gills and large blood vessels that are next to the backbone. Scale it. Gut the fish by cutting open its stomach and scraping it clean. Cut off the head unless you want to cook the fish on a spit. Fish like catfish and sturgeon have no scales. Skin them. Small fish under four inches require no gutting, but should be scaled or skinned.

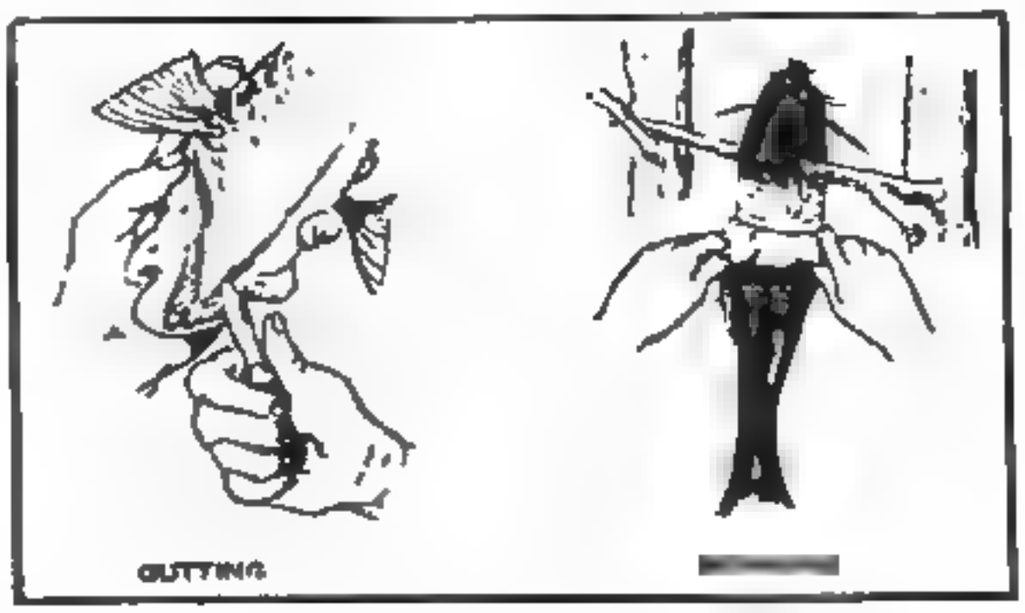


Figure 14.

VII. FIRE.

a. Keep your fire small. In the rainy season or in damp jungles, dry fuel may be difficult to obtain. Carry dry tinder with you to assist in starting your fire. By cutting away the wet outer cover of a sound log, dry fuel can be obtained. Shave dry wood or dead bamboo into thin slivers and stack in tent formation over tinder. Pile heavier fuel around fire and add slowly until fire is well started. If fuel is damp, stack it close to fire to dry out.

b. If the jungle floor is flooded or may become so, build your fire on a hearth of stones or wet wood. If necessary, build a shelter over the fire to protect it from the rain. If the weather gets cold and you need fire for survival, build a screen on the opposite side of the fire from you to reflect the heat toward you. A screen of leaves or branches three or four feet square tied together with fish line or vines will do the job. Tilt the screen with the top toward you. Fiber soaked in insect repellent makes good tinder.

VIII. COOKING.

a. If larger game has been killed, the stomach or skin can be made into a cooking vessel after being cleaned. Fasten three strings into holes made in the top of the wall of the open stomach or skin pouch and tie to the apex of a tripod made of sticks. Fill with water, which can be brought to a boil by putting in fire-heated stones. If sticks are not available and if the ground is not too wet or stony, the skin or stomach pouch can be used as a liner for a hole in the ground. Then fill with water and place fire-heated stones into it.

b. Meat and fish can be stuck onto a sharpened green stick and roasted over a fire.

c. Small animals and birds can be roasted easily. Draw and skin them and wrap in leaves, clay, or mud. Bury in a pit, the bottom of which is lined with heated stones. Fill pit with dirt. In the morning when the pit is opened, you will find the meat well cooked and hot. Larger game can be prepared the same way by cutting into small pieces.

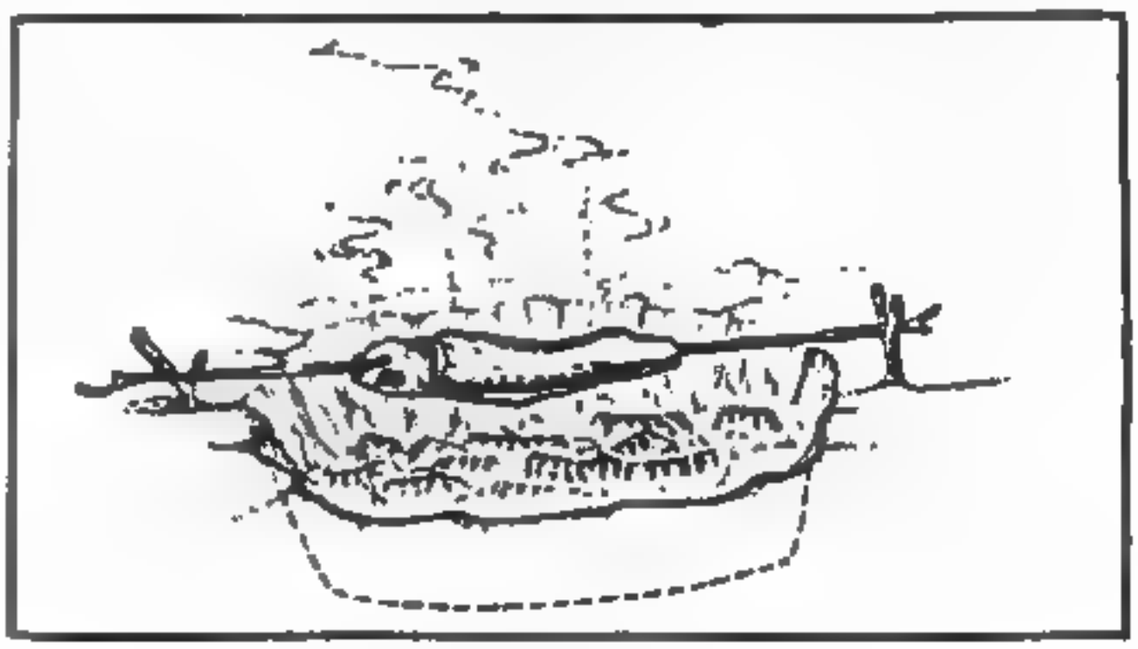


Figure 15. Pit fire.

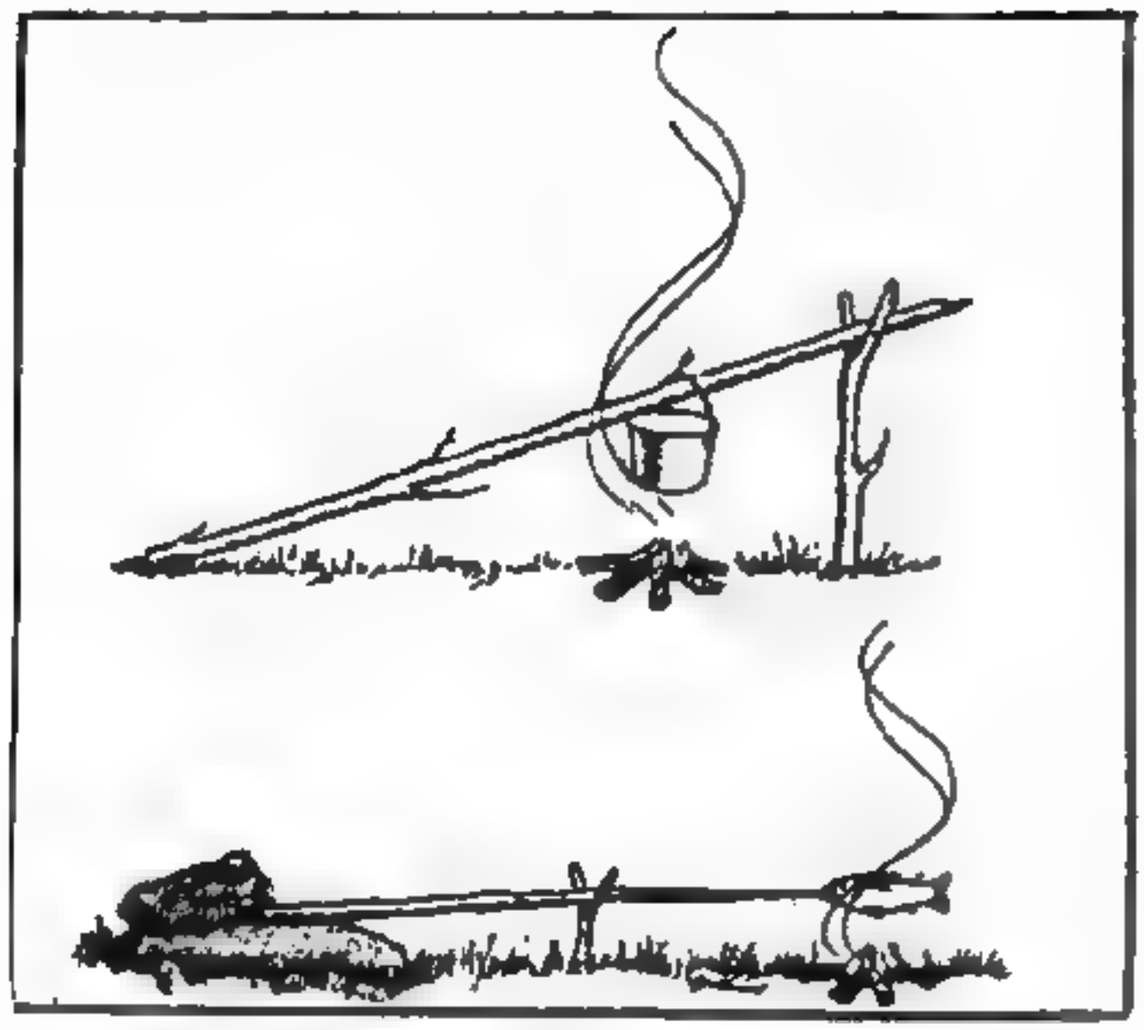


Figure 16. Simple crane.

IX. HEALTH.

a. Care of your person is extremely important. If you have a survival kit, directions for the use of drugs are printed on the containers.

b. Treat every wound or sore as soon as possible. To stop bleeding in the absence of bandages, apply freshly made spider webs. This will assist in the coagulation of the blood.

c. In the absence of toilet paper, use leaves and grasses. Be careful to examine the leaves and grasses for insects. Use no leaves that have any fuzzy or hairy surfaces or are taken from a tree or plant with milky sap, or grass that has a serrated edge. Do not use material that is laying on the ground.

d. Leeches and ticks can be partially avoided by tying cuffs of your jacket at the wrist and the bottoms of your legs outside the boots and applying insect repellent to all openings. Check your clothes and body frequently. Remove leeches and ticks carefully. If pulled off quickly, they may leave their heads in the bite. Infection will result. Wet salt, fire, or lime juice will cause them to withdraw their heads and fall off. Don't hurry the process.

e. In case of heat stroke, heat exhaustion or heat cramps, lower the body temperature by drenching with water or covering the body with wet clothing. Dissolve two salt pills in the equivalent of a cup of water and drink. Rest until all symptoms have passed.

f. In cases of diarrhea when no drugs are available, a tea made from boiled guava leaves or charcoal eaten with hot water will be beneficial.

g. Boils can be brought to a head by applying hot pads.

h. Avoid sunburn. Even a short time in the jungle will reduce your resistance to the sun. Serious infection can result from over-exposure. Keep covered. Do not risk a painful, dangerous burn.

i. MOST IMPORTANT OF ALL, KEEP YOUR HEAD, TRY NOT TO GET TOO TIRED, REST FREQUENTLY, BE CAREFUL, AND DO NOT GIVE UP.

CHAPTER 9

MISCELLANEOUS

TABLE NR. I CONVERSION TABLE - WEIGHTS AND MEASURES

MULTIPLY	BY	TO OBTAIN
Acres	.405	[illegible]
Caliber (inches)	25.4	Millimeter
Centimeters	.3937	[illegible]
Degrees	17.8	Mils
Fathoms	6	Feet
Feet	.1667	Fathoms
Gallons (US)	3.785	Liters
Grains	.00228	[illegible]
Grams	.03527	[illegible]
Hectares	2.471	Acres
Inches	2.54	[illegible]
Kilograms	2.2	Pounds
Kilometers	.6214	Miles
Knots	1.152	Miles per hour
Liters	.2642	Gallons (US)
Meters	1.094	Yards
Miles	1.609	Kilometers
Miles per hour	.8684	Knots
Millimeter	.0394	Inches
Mils	.056	Degrees
Ounces	437.5	Grains

IX-1

TABLE NR. I CONVERSION TABLE - WEIGHTS AND MEASURES (CONTINUED)

MULTIPLY	BY	TO OBTAIN
Ounces	28.35	Grams
Pounds	.4536	Kilograms
Temperature (C) + 17.8	1.8	Temperature (F)
Temperature (F) - 32	.5556	Temperature (C)
[illegible]	.0166	Meters

TABLE NR. II AERIAL PHOTOS

Determining Scale:

Flying Height Method:

Scale = F (Focal length of camera in inches) / H (Altitude above ground in inches)

Map Distance Method:

Scale = [illegible] / GD (Map distance in inches)

Point Designation Grid System

1. Turn photo so that written data is in normal reading position.
2. Draw lines across photo joining opposite fiducial (calibrating) marks.
3. Space grid lines, starting with center lines, a distance equal to 4 cm or [illegible]

IX-2

TABLE NR. II AERIAL PHOTOS (CONTINUED)

4. Number each center line 50 and give numerical values to the other lines, increasing right and up.

5. Read coordinates as any other.

TABLE NR. III LONG RANGE PHOTOGRAPHY
(35-mm Camera & Binoculars)

Procedure.

Camera:

F Stop - M 13 6 x 30 binoculars F 16

M 17 7 x 50 binoculars F 8

Speed - As required by film ASA

Range - Infinity

Binoculars:

Set left eyepiece at zero.

Sight through right eyepiece and adjust to focus.

Set binoculars to camera:

Place left monocular (with reticle) flush with camera lens.

Take picture without moving either binoculars or camera.

IX-3

TABLE NR. IV MAP-DISTANCE CONVERSION

Map distance	Ground distance	Representative fraction (RF)							
		1/25,000	1/50,000	1/75,000	1/100,000	1/200,000	1/250,000	1/500,000	1/1,000,000
One inch	Inches	25,000	50,000	75,000	100,000	200,000	250,000	500,000	1,000,000
	Feet	2,083	4,167	6,250	8,333	16,667	20,833	41,667	83,333
	Yards	694	1,389	2,083	2,778	5,556	6,944	13,889	27,778
	Meters	635	1,270	1,905	2,540	5,080	6,350	12,700	25,400
	Miles	0.4	0.8	1.2	1.6	3.2	4	8	16
	Kilometers	.64	1.3	1.91	2.54	5.08	6.35	12.7	25.4
One centimeter	Inches	9,843	19,685	29,528	39,370	78,740	98,425	196,850	393,700
	Feet	820	1,640	2,460	3,281	6,562	8,202	16,404	32,808
	Yards	273	547	820	1,094	2,187	2,734	5,467	10,936
	Meters	250	500	750	1,000	2,000	2,500	5,000	10,000
	Miles	0.16	0.3	0.5	0.6	1.2	1.5	3	6
	Kilometer	.25	.50	.75	1.00	2.00	2.50	5.00	10.00

IX-4

TABLE NR. V USEFUL KNOTS

Name	Illustration	Use
Square		Join two ropes of same size. (Will not slip, but will draw tight under strain.) To end block making.
Double sheet bend		Join wet ropes, of unequal size, or rope to an eye. (Will not slip or draw tight under strain.)
Bowline		Form a loop. (Will not slip under strain and is easily untied.)
Timber hitch		Lifting or dragging heavy timbers. Is more easily controlled if supplemented by half hitches.)
Clove hitch		Fasten rope to pipe, timber, or post. (It is used to start and finish all lashings and may be tied at any point to rope.)
Sheep shank		Shorten rope or take load off weak spot in rope.
Anchor knot		To fasten cable or rope to anchor

IX-5

TABLE NR. VI MISCELLANEOUS INFORMATION

PRINCIPLES OF WAR

[redacted]

O bjective

S implicity

S urprise

C ommand unity

O ffensive

E conomy of forces

S ecurity

REPORTING INFORMATION

S ize

A ctivity

L ocation

U nit

T ime

E quipment

TERRAIN ANALYSIS

C ritical features

O bservation

[redacted]

O bstacles

A venues of approach & withdrawal

PRISONERS OF WAR

[redacted]

S eparate

S ilence

S peed

S afeguarding

INTELLIGENCE EVALUATION LEGEND.

[redacted]

A-Completely reliable

B-Usually reliable

C-Fairly reliable

D-Not usually reliable

[redacted]

F-Reliability unknown

Information

1-Confirmed by other source

2-Probable true

3-Possibly true

4-Doubtfully true

5-Improbably

6-Truth cannot be judged

IX-6
GUERRILLA TRAINING

1. GUERRILLA TRAINING AIMS: Survive, Obey, Fight.

II. TRAINING PLAN:

a. Steps in planning:

1. Analysis of the mission.

2. Systems for training:

(a) Decentralized.

(b) Centralized.

(c) Combination of Systems.

3. Estimate of training situation:

(a) Training to be conducted.

(b) Personnel:

(1) Available for cadre.

(2) To be trained.

4. Time.

5. Training facilities.

6. Training aids.

7. Equipment.

b. Decisions.

c. The Plan.

d. Principles of scheduling:

1. Facilities preparation of instruction.

DX-7

2. Facilities learning.

3. Use training time effectively.

4. Accommodate the troops.

III. LEGAL STATUS OF GUERRILLAS:

a. Be commanded by a person responsible for his subordinates.

b. Have a fixed distinctive insignia recognizable at a distance.

c. Carry arms openly.

d. Conduct operations in accordance with the laws and customs of war.

IV. FOR SUCCESSFUL EMPLOYMENT OF GUERRILLA WARFARE:

a. The spirit of resistance must be present in a segment of the population.

b. The guerrillas must have the support of the civilian populace.

c. The guerrilla movement must have a sponsor.

V. RECORDS OF GUERRILLAS:

a. Personnel roster; name, rank, date joined, date discharged.

b. Oath of enlistment.

c. Theatre records and reports.

d. Casualty reports.

e. Payrolls.

f. Recording and settling claims.

g. Receipt forms

h. Demobilization:

1. Assembly of guerrilla forces.

2. Collection of arms and equipment.

3. Completion of administrative records.

4. Settlement of pay, allowances, and benefits.

5. Settlement of claims.

6. Awarding of decorations.

7. Care of sick and wounded.

8. Discharge.

9. Provisions of rehabilitation and employment of discharge guerrillas.

VI. GUIDE TO ASSESSMENT OF THE AREA:

a. Initial Assessment.

1. Location.

2. Team morale and condition.

3. Status of guerrillas (local).

4. Security (local): area, attitude of local civilians, escape plan and alternate areas, enemy situation, civilian support available.

b. Principal Assessment (A continuous estimate of the situation).

1. Information of the enemy to include: Disposition; composition, identification, and strength; organization, armament, and equipment; degree of training, morale, and combat effectiveness; operations (recent and current activities of the unit, counterguerrilla activities, and capabilities, current security systems within the unit); unit zones of responsibility; daily routine of the units; logistical support to include: installations and facilities, supply routes, method of troop movement; past and current reprisal actions.

2. Information of security troops and police units: Dependability and reliability to the existing regime and/or the occupying power; disposition; composition, identification, and strength; organization, armament, and equipment; degree of training, morale, and efficiency; influence on an relations with the local

DX-8

3. Information of Resistance Organization: Guerrilla Forces - Size, equipment, organization, states of training, intelligence and logistics systems. Auxiliary, organization, status of training, general dispositions.

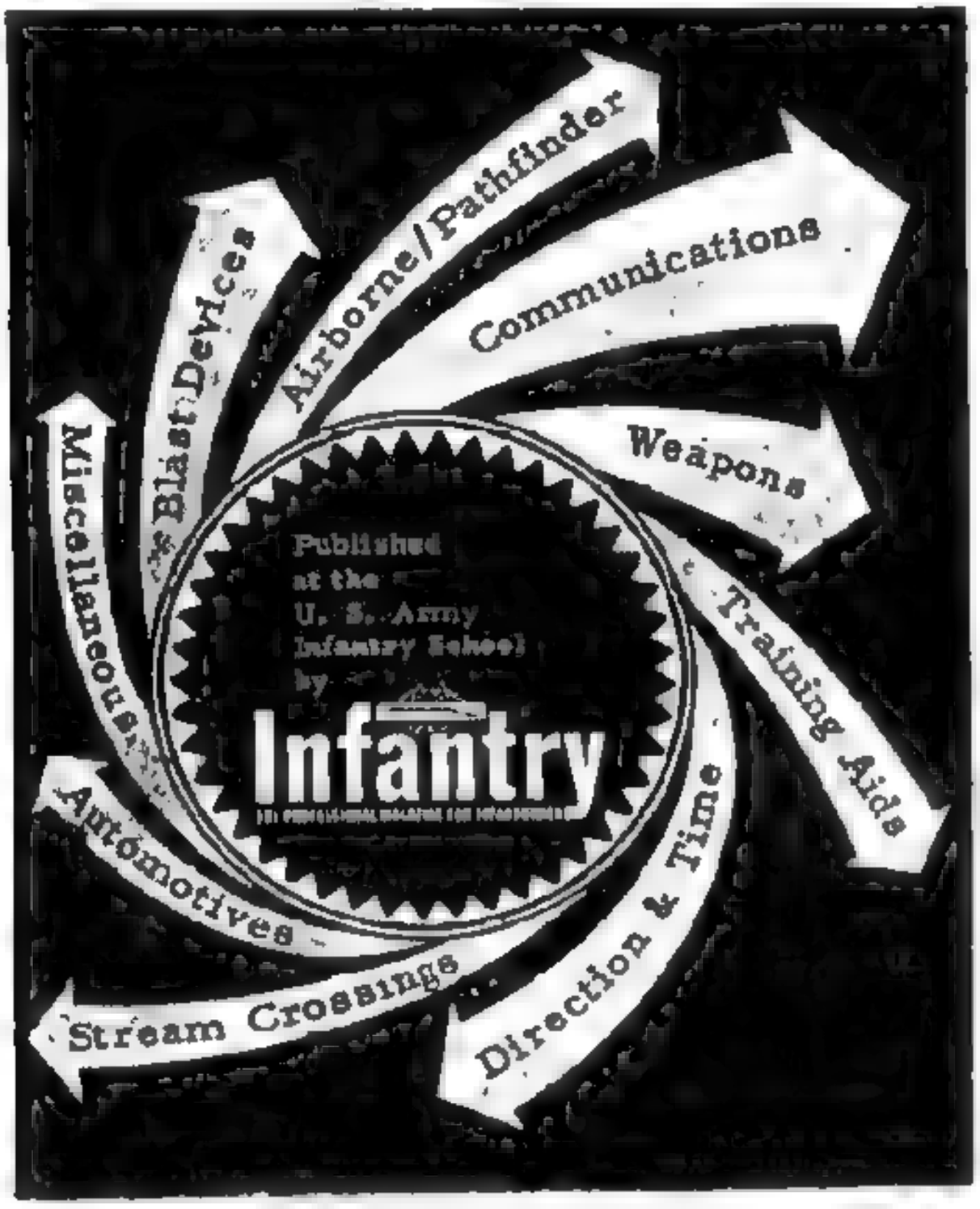
4. Information of the civil government: Controls and restrictions (documentation, rationing, travel and movement restrictions, blackouts and curfews); current value of money, wage scales; the extent and effect of the black market; political restrictions; religion restrictions; the control and operation of industry, utilities, agriculture, and transportation.

5. Information of potential targets: Railroads; telecommunications; POL; electric power; military headquarters and installations; radar and electronic devices; highways; inland waterways and canals; sea ports; natural and synthetic gas lines; industrial plants.

6. Information of the terrain: Location of area suitable for guerrilla bases, units and other installations; potential landing zones, drop zones, reception sites; routes suitable for guerrillas and enemy; barriers to movement; the seasonal effect of the weather on terrain and visibility.

7. Information of the weather: Precipitation, cloud cover, temperature and visibility; wind speed and direction; light data (BMNT, EENT, sunrise, sunset, moonrise and moonset).

Field expedient handbook



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INTRODUCTION

This Field Expedient Handbook is designed to provide junior officers and noncommissioned officers with a handy guide of expedients to overcome some seemingly insurmountable problems in a variety of areas. The handbook is no cure-all, but we hope it serves a definite purpose in the field nevertheless.

The material herein was compiled from past articles in INFANTRY, selected TMs and FMs, and information provided by the USAIS instructional departments. One chapter, however, is largely the result of work by one person, 18-year-old Robert S. Owendoff of Falls Church, Va. In "Direction and Time," Owendoff outlines a unique yet simple method of finding direction--the "shadow-tip method." This method has been adopted by the U. S. Army, U S. Air Force and many other federal agencies and by the American Red Cross and the Canadian Boy Scouts

I. COMMUNICATIONS

Antennas

1. If the antenna for your AN/PRC-6 becomes damaged, remove it and replace it with a 2- or 3-foot length of WD-1 comme wire. The end of the wire should be placed in the auxiliary antenna well. In order to transmit effectively, the wire must be held as close to the vertical position as possible. Try taping or tying the wire to a small branch or piece of wood to provide a brace for the wire. Both the wire and the brace will probably have to be supported by the individual using the PRC-6, however.

2. Normal range of an AN/PRC-10 is 5-8 miles with the Antennas AT-272 and AT-271. This range can be doubled by use of field wire WD-1/TT as a field expedient. This method is recommended for use only when halted.

Materials needed for this type antenna are 53 feet of field wire WD-1/TT, dry stick or peg to insulate field wire from tree, and a short piece of WD-1/TT to ground the battery case (CY-240) of the AN/PRC-10 radio, and a ground rod

Bare one end of the 53-foot section of WD-1/TT and secure it to the receptacle inside the auxiliary antenna connector, extend the field wire its full length up a tree or other suitable support, taking care to insulate the field wire from the tree by use of a dry stick or peg. This end of the field wire need not be bared, but simply tied to the peg. The peg must then be secured to the tree by tying or some other method

The battery case (CY 240) may be grounded by first baring both ends of a strip of WD-1/TT wire, then attaching one end to one of the lower latches on the battery case and attaching the other end to a ground rod.

The 53-foot section of field wire forms the vertical antenna and enables the operator to employ any frequency on the set without any changes in the make-up of his field expedient antenna.

3. The Wave and Vertical Half Rhombic antennas are two field expedient antennas that can be used with FM radio sets. These antennas can be constructed using field wire, lance poles, or existing trees for support.

The antennas will transmit and receive in the direction of the resistor terminated end. They will normally double or triple the rated operating range of the FM radio sets.

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The antennas are terminated with one 400 to 700 ohm carbon resistor. When no resistor is available, the antenna will still increase the range of the FM sets. However, it will not be so great an increase because the antenna will be radiating in two directions rather than one.

When it is anticipated that such an antenna will be needed for communications, a resistor should be used for maximum efficiency.

(See Figures 1 and 2)

The antenna should be connected to the auxiliary antenna connector. Steel wires should be clipped off leaving only the copper wires. The copper wires are twisted together and placed into the center hole of the aux antennas connector, making sure that the wires do not touch any other part of the radio set.

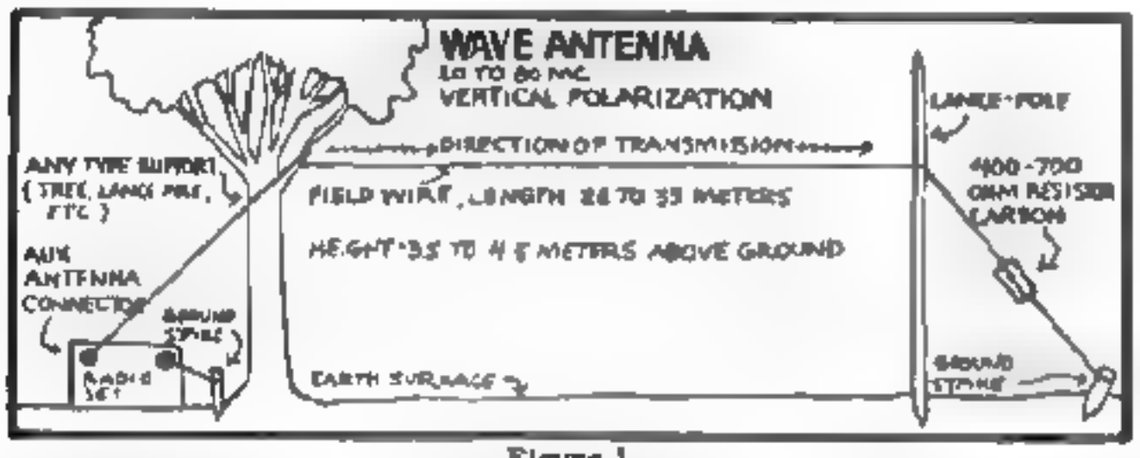

Figure 1

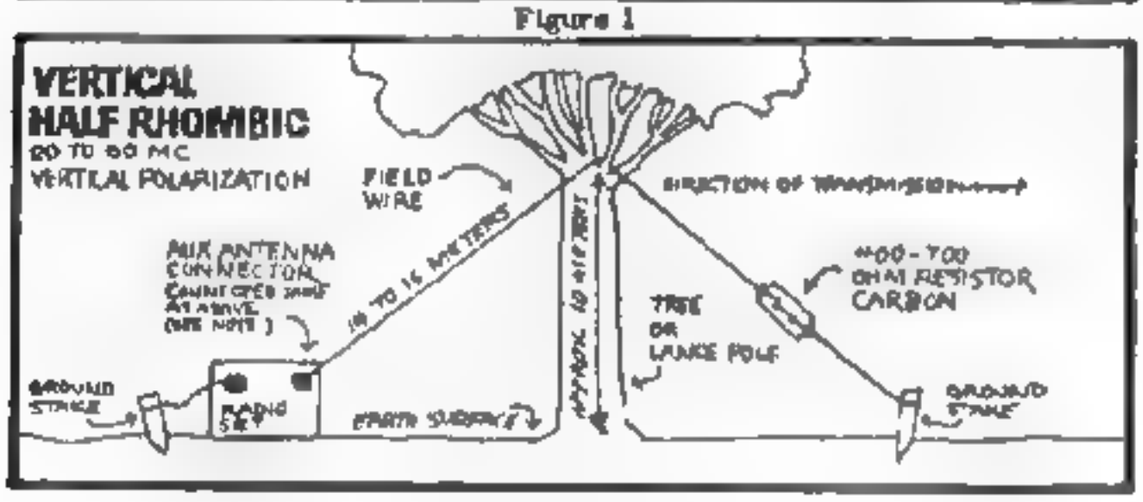

Figure 2

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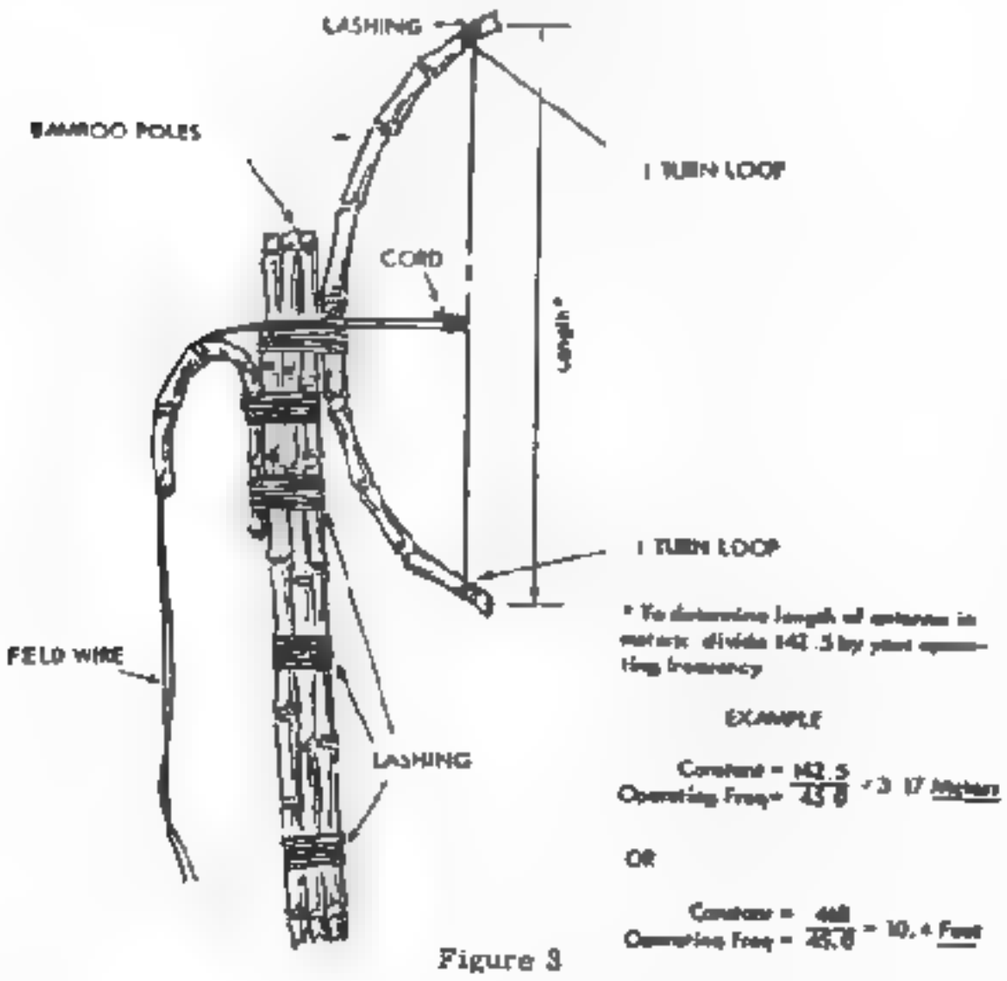
BENT BAMBOO ANTENNA



* To determine length of antenna in meters divide 142.5 by your operating frequency

EXAMPLE

Constant / Operating Freq = 142.5 / 43.8 = 3.17 Meters

OR

Constant / Operating Freq = 468 / 43.8 = 10.4 Feet

Figure 3

4. Bent Bamboo Antenna (See Figure 3)

5. Whip antennas - if the antenna on your vehicular radio becomes damaged or is broken, tie a piece of comm wire to a broomstick or a small tree limb. Insert the end of the wire into the aux antenna connector. The stick or limb can then be held in a vertical position and you should be able to communicate.

To avoid possible damage to a vehicular antenna, tie the whip antenna down with two short pieces of rope and an insulator if you expect to be journeying through low clearance areas.

The whip antennas used with the AN/PRC-6 and -10 radio sets have a directional characteristic. Therefore, best communications are obtained

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(and contact can often be established where it would otherwise not be possible) by ensuring that the antennas on the set sending and the set receiving are perpendicular to the path of transmission, with the flat side of each antenna toward the other set involved.

6. Additional range for AN/PRC-6 - When working with APCs, attach a cable connection on the antenna connector on the PRC-6 to the antenna connector on the radio inside the APC. The same can be done when using any vehicular mounted radio.

Hot Line - Heavy Mortar Platoon

1. Under existing wire systems of the heavy mortar platoon, there are no provisions, personnel or equipment, to permit the FO to enter the wire system. If he does so, there are still two or three switchboards he must go through to reach the FDC. A "Hot Line" can bypass the company and battalion switchboards and enable the FO to contact the FDC directly to avoid delay. Utilizing repeating coils C-161 and a small amount of wire, a private wire line can be established over existing wire lines. The repeating coils must be requested; they are not issued to the FO under TOE (they are TA items).

2. The method of using these coils is the simplex circuit arrangement (See Figure 4). One coil is connected in the OP to a company wire line at a point nearest the FO's position. The FO's telephone is then connected with a

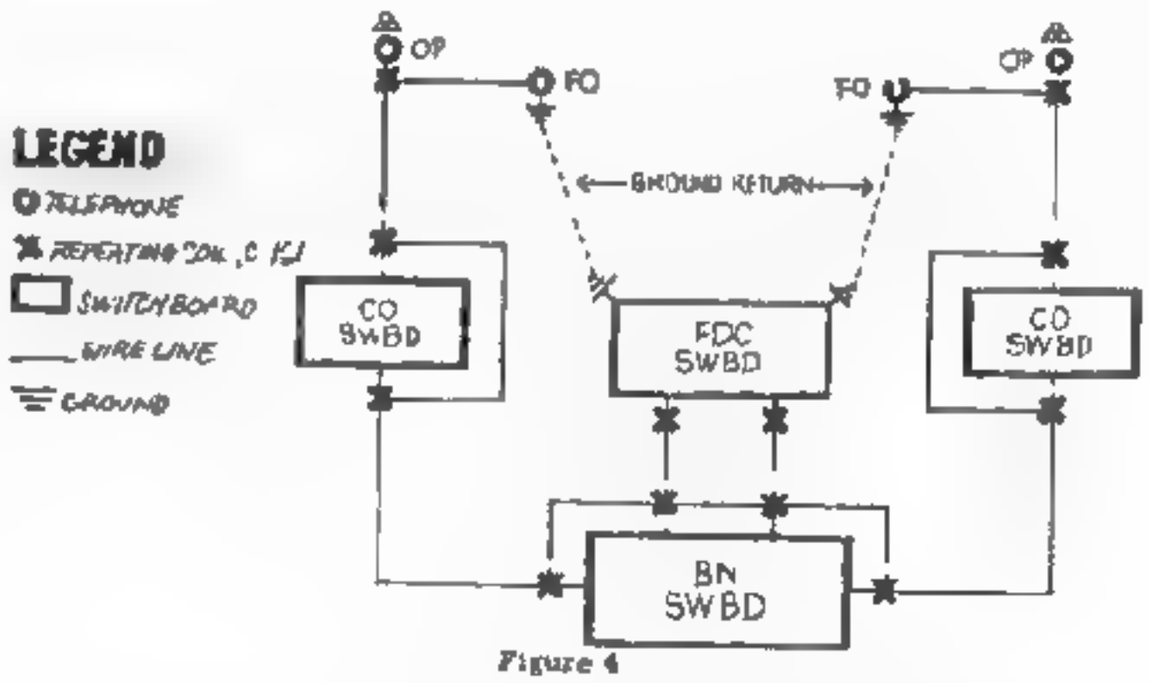

Figure 4

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ground return. The next coil is connected in the wire line before it reaches the company switchboard and forms a by-pass to the other side of the switchboard connecting the company to the battalion with another repeating coil. The fourth coil is placed in the company to battalion line at a point nearest the FDC. From this coil, a line is connected into the FDC telephone or switchboard with a ground return. The "Hot Line" is complete. This permits simultaneous communications over one wire line from the OP to company and the FO to FDC without interference.

The Hot Loop

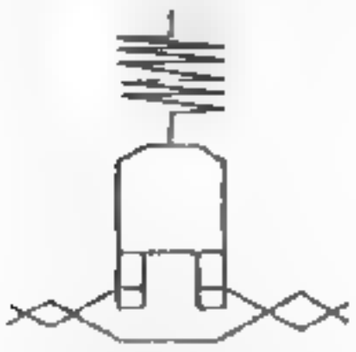
1. This method of hooking up TA-1/PT telephones in the TOE of the platoon allows the platoon to use all its telephones through a distance of 400 meters.

2. In order to communicate and to have audio and visual signaling, the

TA-1/PT telephone must be connected in a series circuit (Figure 5). The two end phones are connected the same as in a parallel circuit, or each conductor to a line binding post. The remaining squad telephones are connected in series (Figure 6). To connect these, take one of the conductors (it makes no difference which one), cut it, strip off approximately 1/2-inch of the insulation on each part of the conductor, then slip another 1/2-inch of the insulation to the tip of the bared wire to hold the strands together. Attach one side of the cut conductor to one line binding post, the other side of the cut conductor to the other line binding post, and the telephone is connected in series.

3. All telephones must be connected properly. If one telephone is not connected correctly, the entire system will not work. The system should be paralleled by radio whenever possible.

4. This set-up can be used as a simulated radio net for practice work on radio/telephone procedure.



SERIES CONNECTION
Figure 5

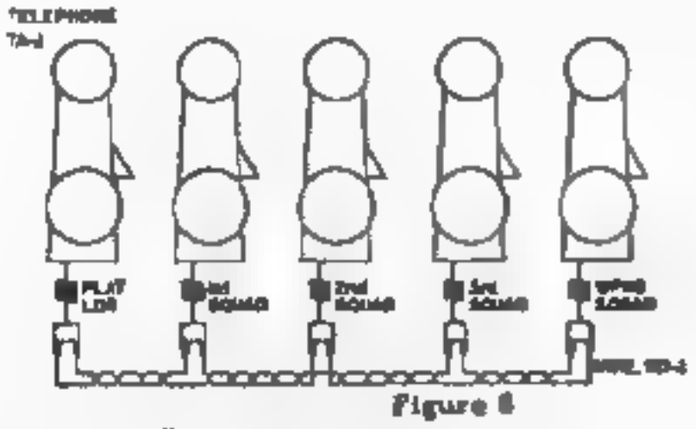


Figure 6

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Ground Return Communications System

1. If your wire line suddenly goes out, take both pieces of wire and place them both in the same terminal post. From the other post run a piece of wire to a ground stake. The same thing must be done at the other end of the line.

2. If both positions follow this procedure, your communications may be restored.

3. If wire is scarce, lay one strand of wire, hook it to one terminal, ground the other terminal, and have line communications. (See Figure 7).

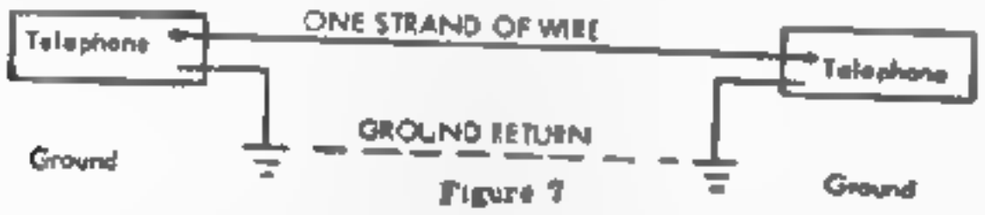

Figure 7

Portable Radios--Immediate Action
AN/PRC-10

1. If other station does not answer, check operation of your set. Turn "Off-Remote-On-Ca." switch to On position, "Squelch control" off (counter-clockwise), "Vol" (Volume) control full on (clockwise); tighten antenna connection and listen for rushing sound in handset.

2. If rushing sound is not heard or is weak, remove and re-insert battery connector.

3. If rushing sound is not heard or continues to be weak, change battery.

4. If rushing sound is still not heard change handset. If none of these steps is effective, your set is defective Send it to a repairman.

5 If rushing sound is heard, push Press-to-Talk switch. If rushing sound continues, change handset. If rushing sound continues, your set is defective. Send it to a repairman.

6. If calibration signal was not heard, change battery and try calibration again. If set will not calibrate, communication may be possible by proceeding as if the set would calibrate and tuning in the vicinity of your assigned channel until a station in your net is heard. This dial setting can be assumed to be your correct channel setting

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AN/PRC-6

1. If other station does not answer, check position of External-Off-Internal switch, turn Volume control full on (clockwise); listen for rushing sound in earphone.

2. If no rushing sound is heard or is weak, check Air Valve. Listen. Remove and re-insert battery connector. Listen. Insert new battery. Listen. If still no rushing sound is heard, set is defective Send it to a repairman.

3. If rushing sound is heard, push Press-to-Talk switch. If rushing sound continues, set is defective. If rushing sound ceases, blow into microphone and new sound (called sidetone) should be heard in earphone.

4. If sidetone is not heard, your set is defective. Send it to a repairman

Field Telephones--Immediate Action
TA-312/PT

If the Telephone TA-312/PT fails to function:

1. First, check the line terminals for firm connections. If they appear to be properly connected:

2. Then, check the selector switch position--if the telephone is being used in field system, the switch should be in the CBS position or MB position If in use with a civilian system, the switch should be in the CB position. If the switch is in the proper position:

3. Then, check the INT-EXT switch position--if using handset H-60/PT, which is part of the telephone, the switch should be in the INT position. If using the auxiliary handset-headset H-144/U, the switch should be in the EXT position.

4. Then, depress the Push-to-Talk switch and blow into the transmitter. If no sound is heard in the receiver, check the battery compartment. One battery cap should be up and the other down

Sound Powered Telephone--Immediate Action

Check to ensure that the wire line is properly installed. If either the transmitter or the receiver is inoperative, the telephone can still be used to communicate. If the transmitter is defective the receiver may be used to both

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transmit and receive; however DO NOT depress the push-to-talk switch to transmit or receive. When it is the receiver that is defective you may use the transmitter to communicate; however you MUST DEPRESS the push-to-talk switch for both transmitting and receiving.

TA-312/PT External Power Source

On the face of the telephone TA-312 there are two chrome screws marked "Bat." These two screws are for applying a field expedient method of connecting an external 3-volt power source such as two BA-23 batteries in series. This method can be used when no BA-30 batteries are available (See Figure 8)

Some batteries with 1/2-volt sections

BA-386 (PRC-25 batteries)

BA-279 (PRC-10 batteries)

BA-270 (PRC-6 batteries)

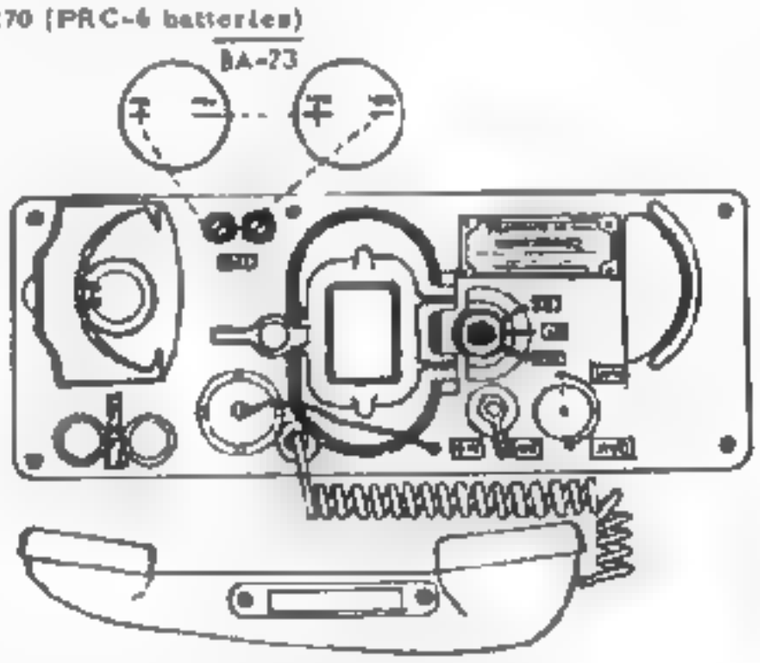

Figure 8

TA-312/PT Visual Signal

It is possible to receive a visual signal with the Telephone Set TA-312/PT by connecting an adapter plug, U-184/GT, to the binding post and turning the volume control to the low position.

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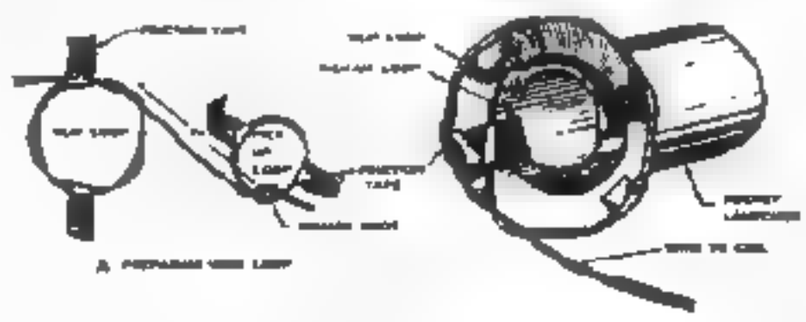
Field Expedient Wire Laying

3.5-inch Rocket Launcher (Figure 9)

Dummy Rifle Grenade w/dispenser MX-306A/G (Figure 10)



Steps in Using 3.5-Inch Rocket Launcher To Lay Wire.

Figure 9

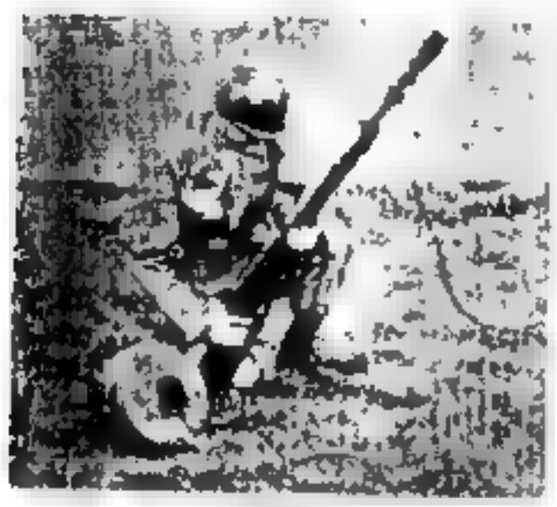


Figure 10

Batteries

1. Before placing a battery in a radio set, peel the cellophane off the socket. If you do not, you will lose your contact when good contact is desirous

2. To protect your equipment, remove the battery when the equipment is not in use This precludes battery acid damaging internal components.

3. Sub-freezing temperatures will affect the batteries used in the AN/PRC-6 and -10 radio sets, making them ineffective as a power source. Such batteries may be restored to use. Carry spare batteries inside your field jacket keeping them warm with body heat. Rotate batteries from jacket to equipment when a loss of power is noticeable.

Storage of Comms Equipment

One way to prevent rust and mildew on equipment in storage is to line storage cabinets with aluminum foil and hang a 100-watt bulb in the cabinet.

Genera Upkeep

1. Since the audio caps for your receiver-transmitters are a little tricky to put on, put a small dab of white paint on the connector and cap so that the cap will slip on easily when the marks are lined up.

2. A light coat of black enamel, carefully applied to hardware on canvas equipment, can retard corrosion for a year or so.

II. Stream Expedients

Poncho Raft

1. When constructed using two rifles and the normal clothing and persons. equipment of two individuals, it will support 110 pounds of dead weight. After being submerged for 30 minutes, it will still support 80 pounds. Two non-swimmers each weighing 160 pounds, may be supported by the raft.

2. To build the poncho raft: (See Figure 1)

a. One poncho is placed on the ground with the hood facing up, after the neck opening is closed and tied off with the drawstring.

b. The individual weapons are then placed on each side of the neck

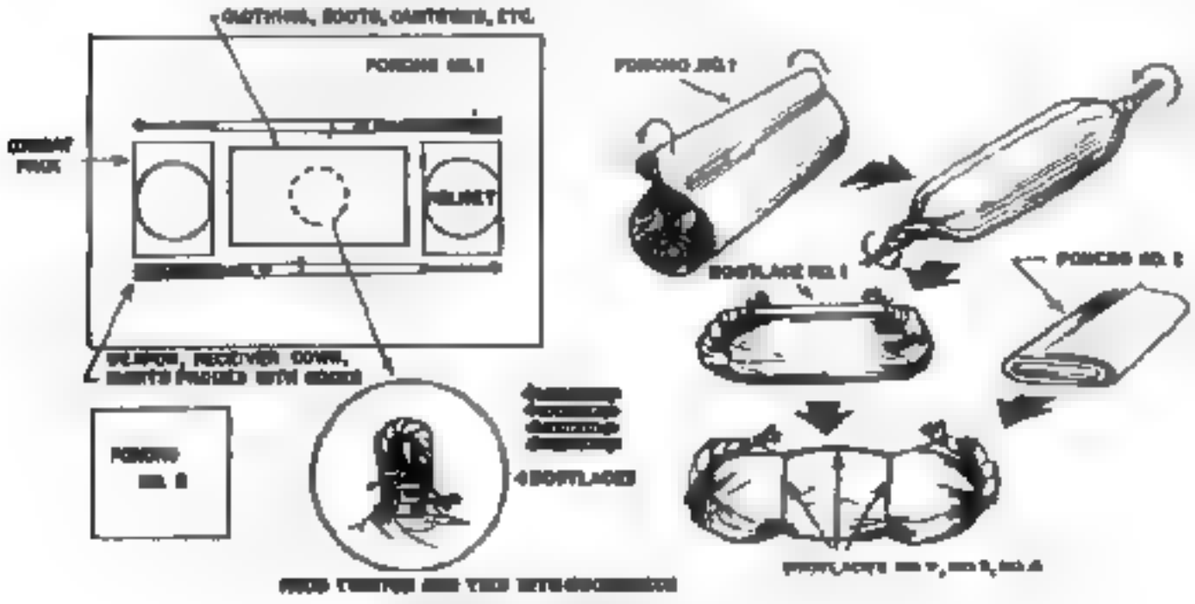


Figure 1

opening, butt-to-muzzle and running the long axis of the poncho. Operating rod handles face toward the center.

c. The laces are taken out of both individuals' boots. Socks are used to pad the front and rear sights.

d. Packs are placed inside and at the ends of the two weapons.

e. Clothing is then neatly folded and placed inside the weapons and the packs. Care should be taken to place clothing inside as level as possible.

f. Harness and webbing are placed atop the clothing. If helmets have been worn, they are placed atop the packs.

g. Boots are placed atop the harness and attachments.

h. Both members of the buddy team move to the flank of the raft and

fold up sides of the poncho over the top of the equipment. Snap together all snaps on the sides.

i. Working together at the center, the buddy team begins rolling the sides of the poncho toward the equipment. Roll tightly and together so that the roll does not become loose. The poncho is rolled tightly down to the equipment.

j. Roll the poncho out to both ends, keeping as tight as possible. At the ends, twist the poncho to form a pig-tail. Keep the pig-tail tight.

k. While one member of the buddy team holds the pig-tails to keep them from untwisting, the other member ties the pig-tails tightly together with one of the boot laces.

l. Spread the second poncho on the ground, hood closed and facing up. If more buoyancy is desired, brush and grass may be placed between this poncho and the first.

m. Place the equipment bundle formed with the first poncho in the second poncho with the pig-tails facing downward.

n. Roll the sides of the second poncho the same as the first. Tie off the pig-tails with the second boot lace.

o. The third and fourth boot laces are tied around the ends of the raft going underneath the boot lace tied to the pig-tails.

p. The raft is now ready to be placed in the water. (See Figure 2)

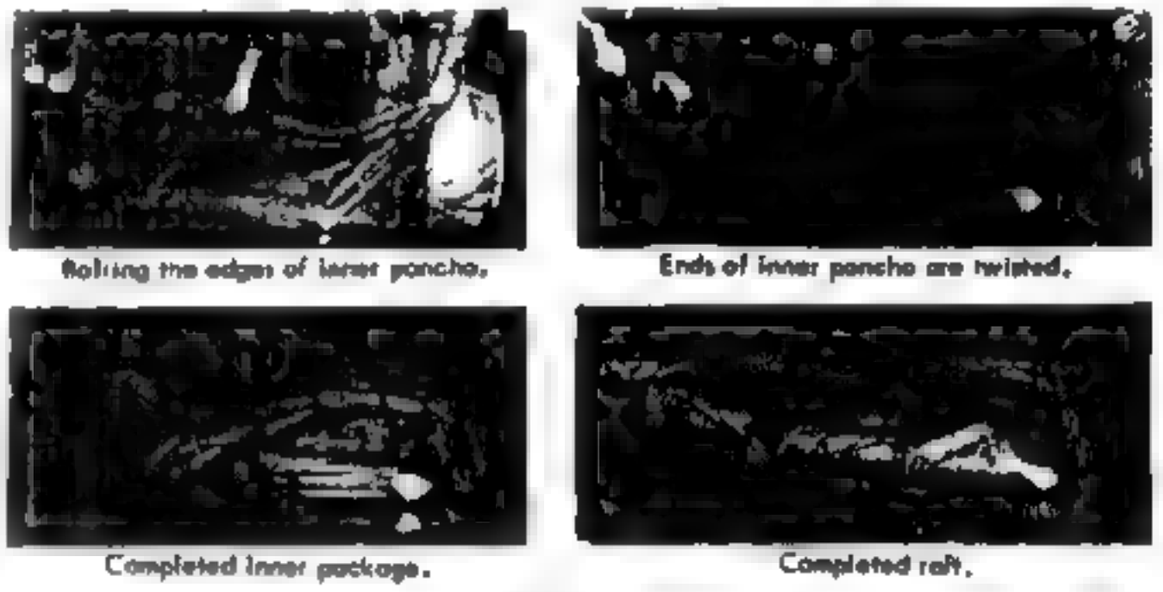


Figure 2.

River Navigation

A strip map can be drawn on luminous tape, either to scale or schematically, showing turns and bends in a river, and the azimuth and distance of each leg of the river along the route.

Rope Bridge

1. Send one man across the stream with the ends of two ropes. Before sending him across, a butterfly knot should be tied on each rope at a point where, when the far end of the rope is secured to a tree, it is about 1/3 of the way across the stream, nearer the friendly side. (A mountaineer s snaplink placed in the loop of the butterfly knot will prevent rope-to-rope contact.) Each rope is then passed around a tree on the friendly side, and then slipped through its snaplinks.

2. The man across the stream ties each rope to a tree, one near the base and the other about five feet higher. On the near bank, the ropes are spread similarly, then pulled as tight as possible and tied off. A short length of rope is then tied from the upper to lower rope to keep them from spreading as men pass over.

3. Rope chart (Figure 3)

4. A knot can reduce rope strength as much as 30%. Sharp bends around corners can halve the strength, and exposure and heat can reduce rope strength by as much as 20%

Diameter (inches)	Circumference (inches)	Weight per 100' (pounds)	Grade A Manila Breaking Strength	Grade A Manila Safe Load	Sisal Breaking Strength	Sisal Safe Load
¼	¾	1.71	550	150	440	120
⅜	1¼	3.45	1275	325	1020	260
½	1½	7.26	2650	900	2120	590
⅝	2⅛	[illegible]	5400	1350	4320	1080
1	3	26.5	9000	2250	7200	1800
1¼	3¾	40.8	13,500	3200	10,800	2700
1½	4½	58.8	18,500	4620	14,800	3700
2	6	106.8	31,000	7750	24,800	6200

Characteristics of new manila and sisal rope.

Figure 3

1. PACE-MEASURING METHOD (Figure 4)

a. Spot a landmark on the far shore (point A).

b. Place a stake on the near shore (point B) exactly opposite the landmark on the far shore. The line of sight from this stake to point A is called line AB.

c. Walk along the near shore at a right angle to line AB for any even number of paces. At this point (point C) place a second stake. The line of sight from point B to point C is line BC

d Continue walking along the same line for half as many paces as on line BC At this point (point D) place a third stake. The line of sight from point C to point D is line CD.

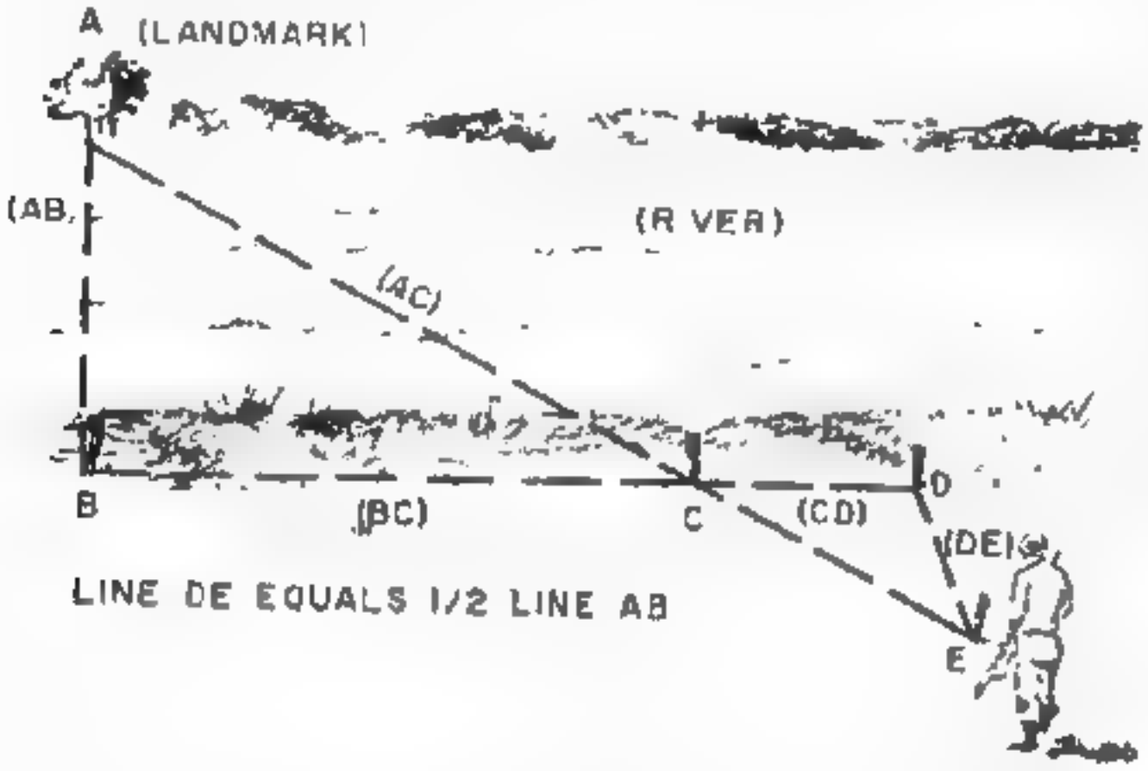


Figure 4

e. At the third stake (point D), turn away from the river and walk at right angle from line BCD until you can see stake C and the landmark, point A, on a straight line of sight. At this point place a fourth stake (point E). The line from point D to point E is line DE.

f. Count the paces from the fourth stake, point E, to point D, convert your paces to feet or meters. Double the distance of line DE for the distance across the river.

2. 45-DEGREE RIGHT TRIANGLE METHOD (Figure 5) - requires an angle measuring device such as a prismatic compass. Method is based on fact that the two legs of an isosceles right triangle are equal.

a. Spot any landmark on the far shore (point A).

b. Place a stake on the near shore (point B) exactly opposite the landmark on the far shore.

c. Using an angle measuring device such as a prismatic compass,

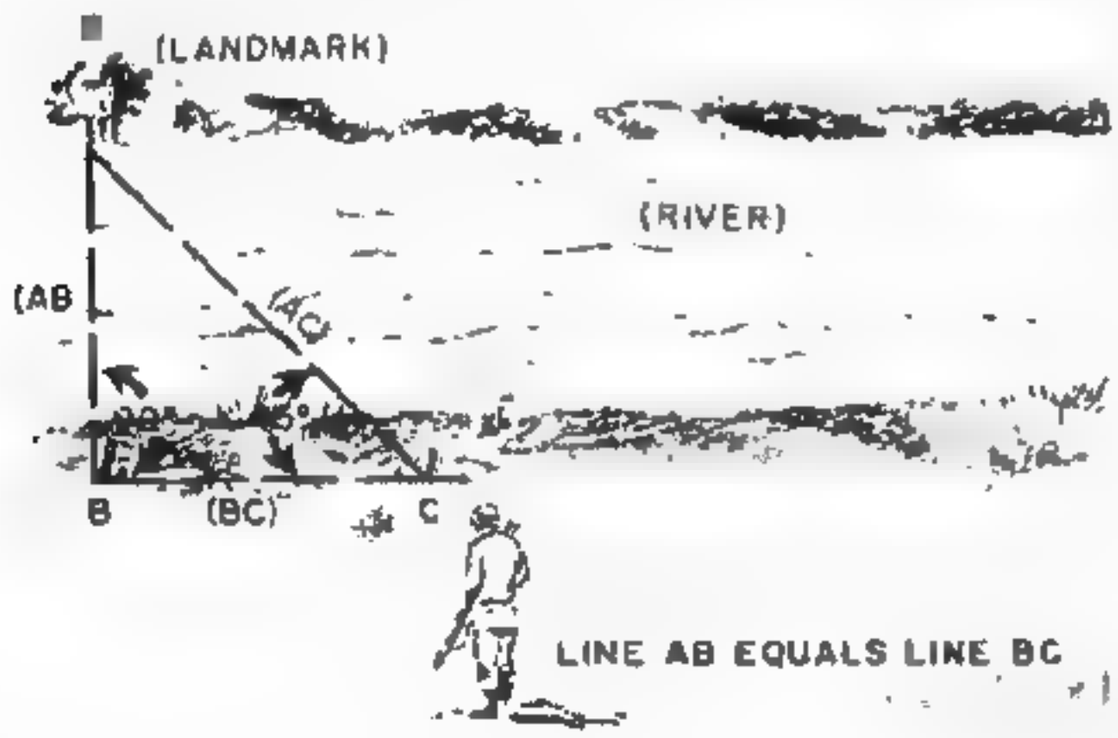


Figure 5

walk along the near shore at a right angle to line AB. The line you are walking will be line BC

d. Walk along line BC until you can see the landmark on the opposite shore (point A) so that line AC intersects the line you are walking, line BC, forming a 45-degree angle. At this point (point C) place the second stake.

e. Count the paces from point C to point B and convert the paces to feet or meters. The distance of line BC is equal to the distance of line AB, the width of the river.

APCs Crossing Stream

A nylon rope is tied to one of the front lifting eyes of the M.11. The free end is then taken to the far bank by boat or by a swimmer. A squad of men (or more) is also dispatched at this time to the far bank. As the M113 enters the water, the line is kept taut by the squad of men. If the current is not too swift, the men can position themselves just upstream. For swifter currents, they can position themselves further upstream so as to effect more lateral

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pull. If need be, another rope can be fastened to the rear lifting eye to keep the M113 from broaching. However, normally one rope plus the propulsion of the M113 are all that is required. If nylon rope is not available other types may be utilized. Nylon rope has the advantages of being strong, light and buoyant. It does not become waterlogged after long use.

Logs to Cross Ditches

1. A convoy of mixed wheeled vehicles may cross such ditches as are too deep to drive through by using five logs. The logs should be approximately 10 inches in diameter, from 3 to 4 feet longer than the span and positioned as indicated in Figure 6. This arrangement will pass a wheeled vehicle convoy without re-positioning the logs. To prevent the logs from spreading apart, stakes should be driven into the ground on both sides of the logs, and the logs should be lashed together at the center with a chain, wire, or rope Only two logs would be required to pass a dual-wheeled vehicle across a ditch. The front wheels can be converted to duals by using the spare wheels or by removing the outer wheels of one of the sets of rear duals, and allowing the dual wheels to straddle the logs as the vehicle crosses.

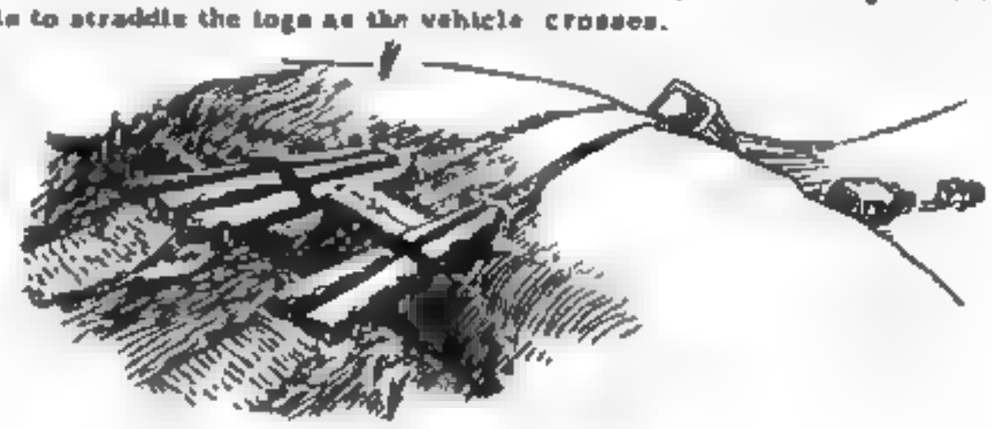

Figure 6

2. Four logs would be necessary to pass a vehicle equipped with single wheels. By lashing the logs together in pairs, the wheels would ride between the logs. A guide must be provided to ensure that the vehicle and logs are aligned properly.

III. WEAPONS

1. A tent rope may be used as a field expedient cleaning rod for all small arms.

2. Range determination and the M14 (Figure 1) - A new expedient method for the rifleman to determine range with his weapon works on the principles of stadia. The stadiometric ranging method of determining distance depends on solving the triangle established by the angle subtended at the observer's position by an object of known size. The main requirement is for the firer to get firmly established in his mind what a length of one meter looks like. For instance, all men measure about 1 meter from top of head to crotch. This distance is also the size of the E-type silhouette. The average doorway of a house is twice 1 meter high (2 meters) as is the armored personnel carrier.

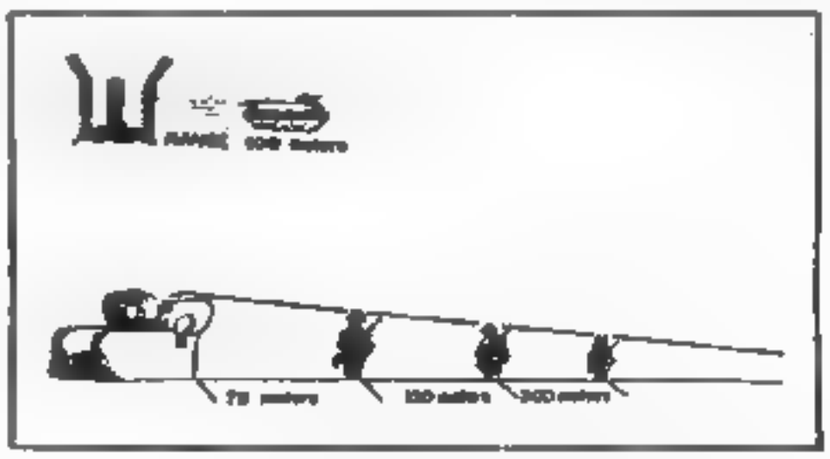

Figure 1

Because the target will appear to be smaller at greater distances, an accurate method of determining how much smaller the target appears would determine the distance. With the eye positioned directly above the stock, 6-9 inches behind and not looking through the rear sight, the appearance of the size of the target in relation to the size of the front sight would establish the range to the target.

The front sight blade of the M14 is 6 millimeters high

The wings (or front sight guards) are 11 millimeters high.

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The small of the stock, 85 centimeters from the front sight, provides a point at which to position the eye each time for consistent results (a small stripe on the stock helps the firer to reposition his eye each time). Solving the triangle:

If a 1-meter target appears as high as the front sight wing, the range is 75 meters.
If the target appears to be the same height as the front sight blade, the range is 150 meters.
One-half as high as the front sight blade is, of course, 300 meters.
Half-way between the height of a wing and the blade is 100 meters.
Ranges to 2-meter targets are doubled. If an APC appears half as high as the front sight blade, the range is 600 meters.

3. LAYING THE MACHINEGUN BY THE USE OF FIELD EXPEDIENTS. Field expedients include the use of stakes and other devices to engage preselected target areas. Proper use of one or a combination of field expedient techniques will aid in employing the machinegun in its predetermined fire role. These techniques may be used in conjunction with the traversing bar and traversing and elevating mechanism method. The field expedient method serves to supplement and enhance the employment of the gun in engaging preselected target areas. This method is not so effective as the traversing bar and traversing and elevating mechanism methods and requires additional material. Field expedients serve as a primary means of engaging preselected target areas in a secondary sector during periods of limited visibility, and they may be used as a primary means in the primary sector until time or conditions of visibility permit recording data from the traversing bar and traversing and elevating mechanism. If a gun crew is replaced for any reason, field expedients being employed must be explained to the relieving crew.

a. THE AIMING STAKE TECHNIQUE. The principal advantage of this technique is that no light is required at the gun position at night. It is not effective when visibility is so limited that aiming stakes cannot be observed. The gun is laid to hit a target area, and the following procedure is used:

(1) The rear sight slide is raised to its uppermost position in the rear sight leaf.

(2) A strip of luminous tape or luminous paint is placed at least halfway up the rear of the front sight post.

(3) An aiming stake, marked with a strip of luminous tape or paint, is taken one or two meters forward of the gun position.

(4) The gunner moves his head slightly to the right causing the front sight post to appear in the left corner of the rectangle formed by the rear sight slide and rear sight leaf. Under the gunner's directions, the stake is aligned and driven into the ground in such a way that the two pieces of luminous material are adjacent (aligned for direction) and the top edges of

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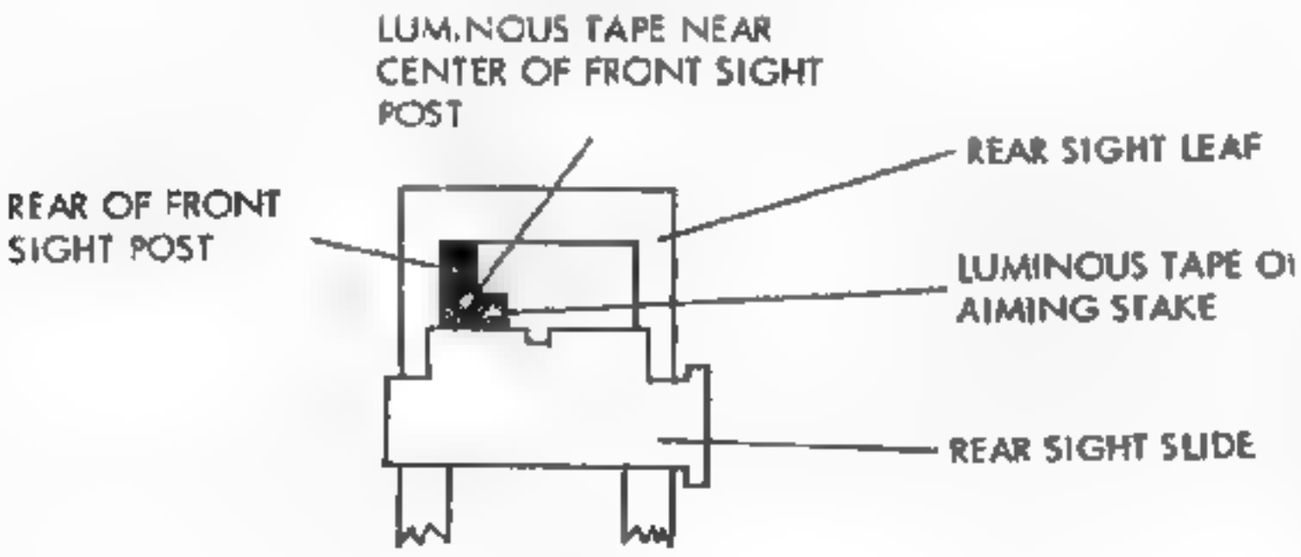
both pieces of material are level (aligned for elevation), presenting a sight picture such as the one depicted in Figure 2. The gunner must maintain the correct position and grip throughout the procedure and, when engaging targets, must cause the front sight post to appear in the left of the rear sight by again moving his head slightly to the right.



Aiming stake technique of engaging targets during periods of limited visibility.

Figure 2

b. THE BASE STAKE TECHNIQUE. This technique is used to define sector limits and may provide the lay for the final protective line or other preselected target areas which exist along a primary or secondary sector limit. The base stake method is effective in all conditions of visibility and requires a minimum of additional material. The following procedure is used:

(1) Define a limit of sector. Lay the gun for direction along one sector limit and emplace a stake along the outer edge of the folded bipod legs, taking up the "play" as the legs rotate slightly on the barrel. The same procedure is used for placing a stake along the opposite sector limit.

(2) Lay the gun to engage a final protective line. Move the muz-

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zle of the weapon to a limit of sector. Adjust for elevation by driving a stake into the ground so the top of the stake is under the gas cylinder extension, allowing a few mils of depression to facilitate covering irregularities in the terrain (Figure 3).

SECTOR LIMIT AND ELEVATION STAKES

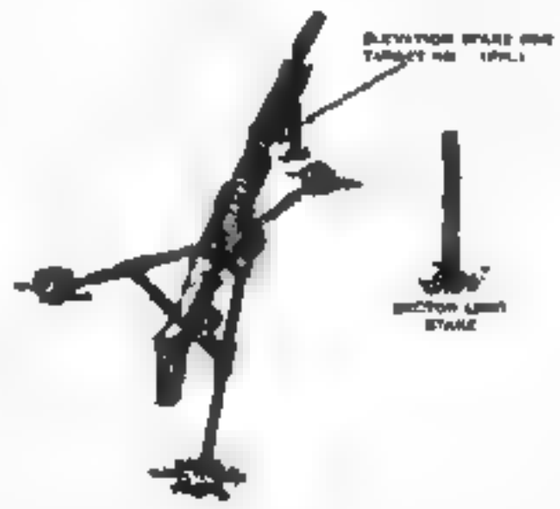

Figure 3

(3) Lay the gun to engage other target areas on a sector limit. In a primary sector this is accomplished by using the procedure in (2) above; the only difference is that no depression is allowed for irregularities in the terrain. In a secondary sector when the gun is mounted on tripod, and the traversing and elevating mechanism is removed, the procedure described in (1) above is used in addition to driving in an additional stake under the gas cylinder extension to fix the elevation.

c. THE NOTCHED STAKE OR TREE CROTCH TECHNIQUE (Figure 4). The notched stake or tree crotch technique is used with the bipod mounted gun to engage preselected target areas within a sector or to define sector limits. This method is effective in all conditions of visibility and requires a minimum of additional material. To employ this method the following procedure is used:

(1) The stock of the weapon is placed in the rests of notched stakes or tree crotches and adjusted to hit desired targets or to define sector limits.

(2) Shallow trenches or grooves are dug for the bipod feet. These trenches or grooves act as a pivot point for the weapon, permitting rotation

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of the bipod feet as the stock is moved from one crotch or stake to another.

(3) The weapon is held and fired using the position and grip employed in bipod firing.

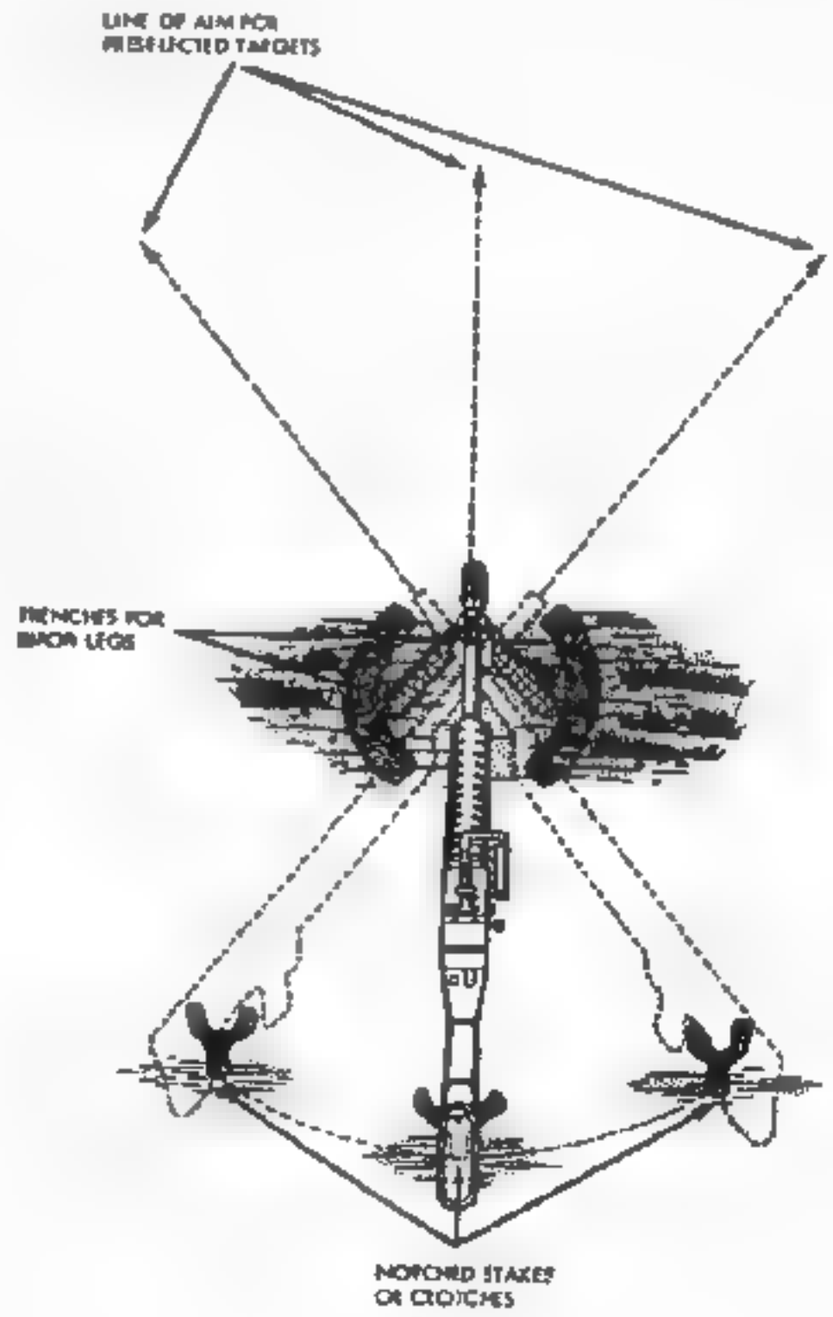

Figure 4

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d. THE HORIZONTAL LOG OR BOARD TECHNIQUE (Figure 5). This technique is used with the bipod or tripod mounted machinegun to mark sector limits and provide sector of graze fire. The horizontal log or board technique is effective in all conditions of visibility. The following procedures are used

(1) THE BIPOD MOUNTED GUN. Place a log or board beneath the stock of the weapon in such a way that the stock can slide across it freely.

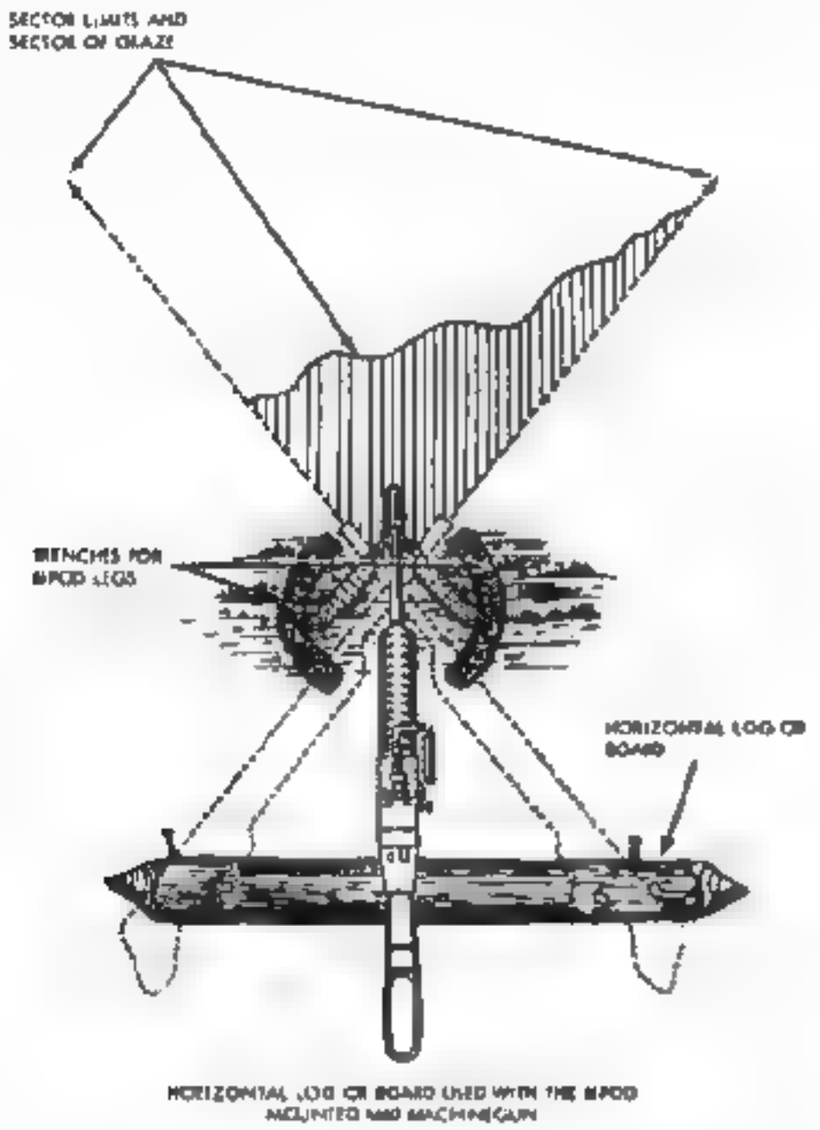

Figure 5a

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Dig shallow trenches or grooves for the bipod feet to allow rotation of the feet as the stock is moved along the horizontal log or board. Adjust the bipod legs to the desired elevation. The sector limits may be marked by notching or placing stops on the horizontal log or board. Bipod firing position and grip are used.

(2) THE TRIPOD MOUNTED GUN. Place a log or board beneath the barrel of the weapon. The log or board should be positioned in such a way that the barrel, when resting on the log, will be at the proper elevation to obtain sector of grase fire. The limits of sector are marked, when appropriate, as discussed in (1) above.

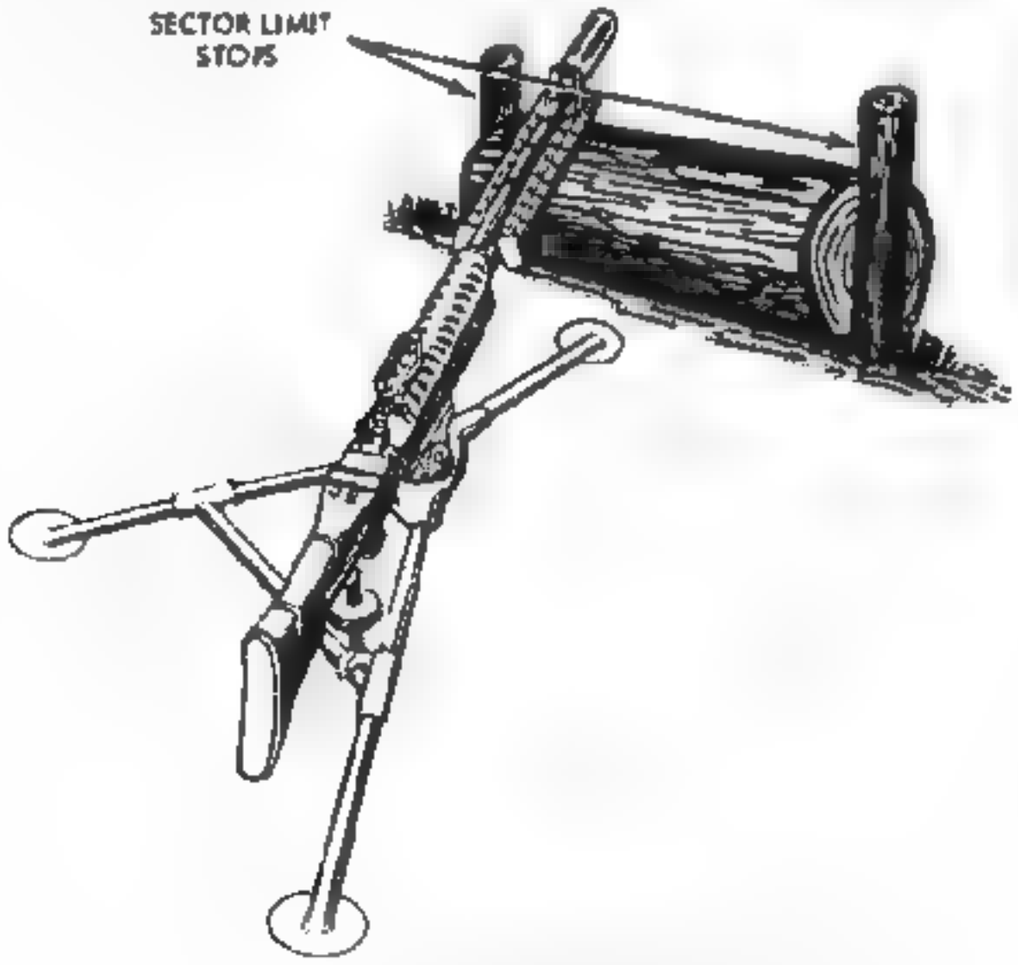

Figure 5b

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4. PREPLANNED FIRES. In addition to engaging appropriate visible targets, which have priority at all times, the squad members must be able to deliver preplanned fires during periods of extremely limited visibility. These fires can be used to cover likely avenues of approach, anticipated enemy automatic weapon positions, and probable enemy assault positions. Such preplanned fires would be delivered on order only and could be used to break up an enemy attack before it reached the assault stage. Preplanned fires can also be used to provide mutual fire support within the squad by having individuals cover portions of adjacent sectors that are defiladed from other squad members. The field expedients for delivery of this preplanned fire must be emplaced and their alignment verified during daylight. Preplanned fire data should be recorded on a range card or sector sketch.

a. RIFLES AND AUTOMATIC RIFLES. Preplanned grazing fire can be delivered with rifles and automatic rifles by using field expedients as shown in Figures 6 and 7. The weapon is placed in the rests and aimed to hit the desired point or cover a sector with grazing fire. The rests are adjusted so that when the weapon is placed in them, it will be pointing in the desired direction and will hold the weapon at the desired elevation. To fire from the rest, the individual places the weapon in the rests with his right shoulder firmly against the butt. He can deliver grazing fire across his sector or at a point target as rapidly as he can manipulate the trigger. He must hold the weapon in the rests in the exact position in which it was held when it was sighted in. By using additional stakes (Figure 6) or a horizontal board or log

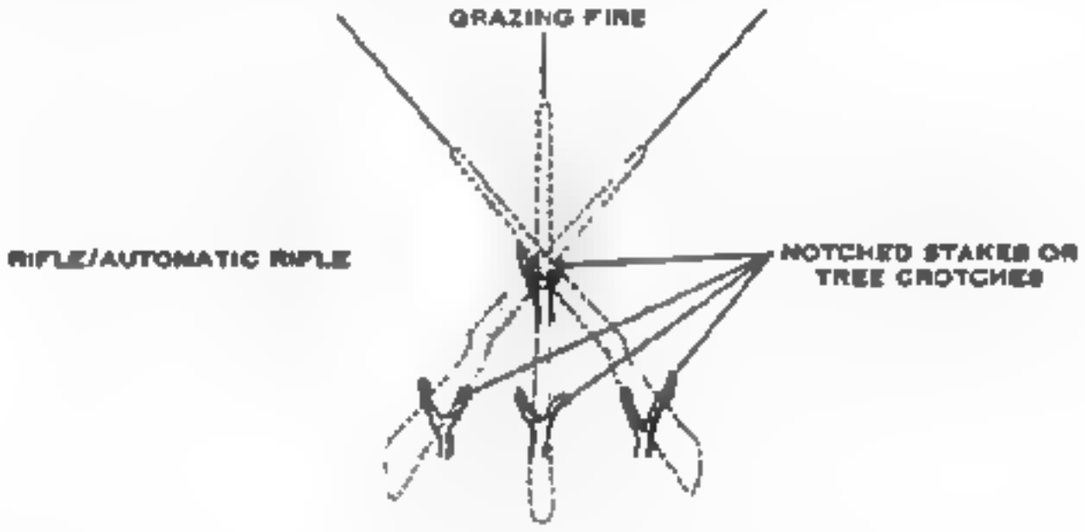

Figure 6

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(Figure 7), the individual can align the weapon for grazing fire along more than one line or to cover an entire sector depending on the terrain.

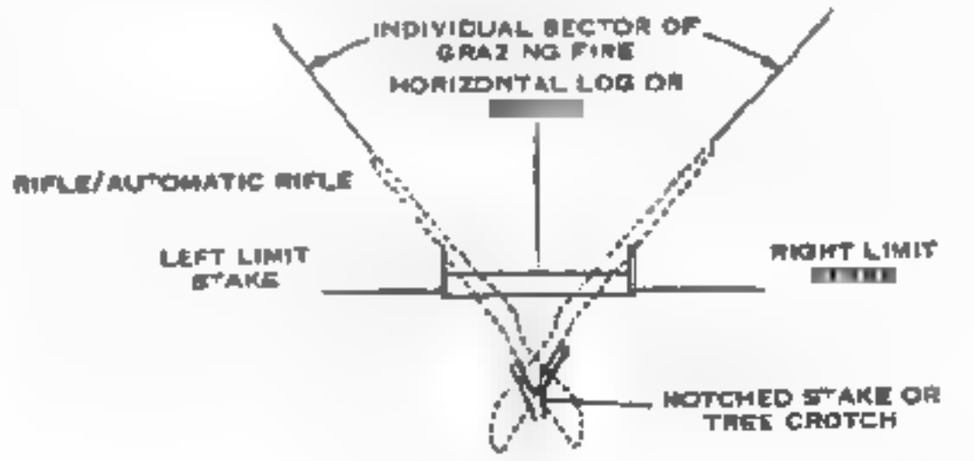

Figure 7

b. GRENADE LAUNCHERS. Preplanned high angle fire can be delivered with grenade launchers by using the field expedient shown in Figure 8.

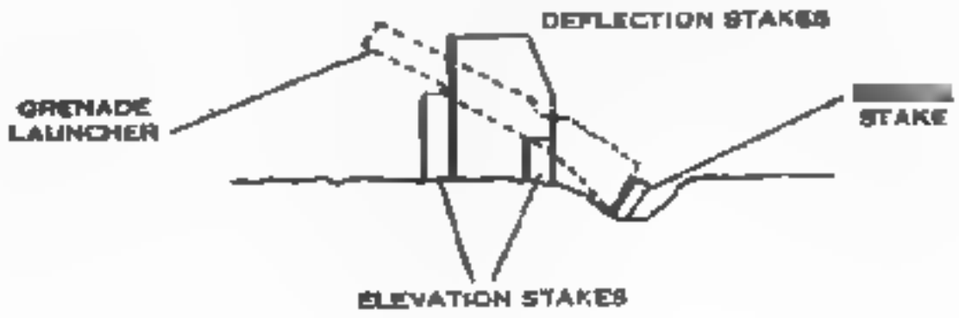

Figure 8

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5. EXPEDIENT NIGHT SIGHT AND SIGHT PICTURE FOR THE AR (See Figure 9).

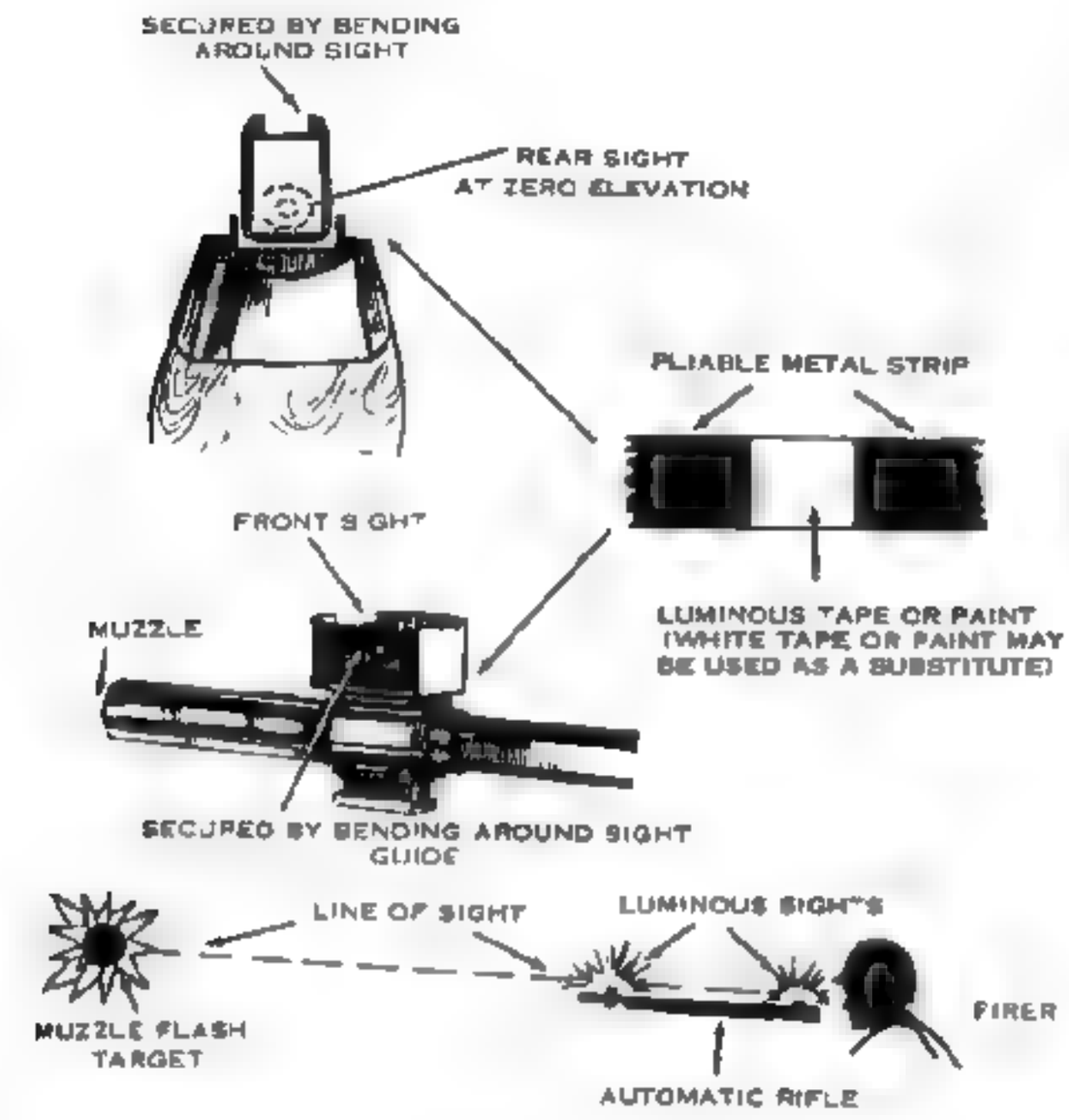

Figure 9

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V. Airborne/Pathfinder

1. LANDING ZONE ASSEMBLY - Personnel being transported in aircraft tend to become disoriented. If for any reason the aircraft is unable to land in the objective area on the heading as given in the briefing prior to the conduct of the airmobile operation, some method should be announced that would give the passengers the heading of the aircraft upon landing. The crew chief of the aircraft can draw a sketch (acetate board can be used) of the objective and designate the heading of the aircraft upon landing. This information would come from the aviator flying the aircraft and would be passed on to the senior supported unit member aboard the aircraft. This information should then be given to all personnel aboard the aircraft. Upon landing and departing the aircraft, all personnel will then know in what direction to go to the assembly area.

2. Hand-held parachute flares, when fired vertically, can be used to approximate wind drift for parachute drops.

3. When MX-290 lanterns are not available, small fires may be substituted to mark fixed wing landing strips and helicopter landing sites. Tin cans filled with sand and gasoline will burn even in a moderate wind.

4. Five-cell flashlights with lens from MX-290 lanterns can substitute for the SE-11 signal light to signal aircraft.

5. During parachute operations, a handkerchief can be a possible substitute for a helmet chin strap.

6. PONCHO PARACHUTE - Capacity: Approximately 80 pounds.

MATERIALS NEEDED.

a. A poncho.

b. A static line, 12-15 feet long (80-pound test tape, 80-pound test fishline, or the cord part of a canvas repair kit will do).

c. 8 suspension lines, each 6 feet long (tent ropes or lengths of WD-1/TT field wire)

d. 1 break cord, 1 foot long (plain cotton twine which must be weaker than the static line)

e. 1 suspension loop, 12-15 inches long (web belt, clothesline, or the wire from a box of C-rations).

f. 1 load cover (meat wrapping paper or a standard tactical map will suffice).

g. 1 hamstring, 6 feet long (a tent rope or drawstring from a poncho or field jacket).

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FUNCTIONS OF COMPONENTS

a. Suspension lines - suspend load from parachute.

b. Break cord - after the static line deploys the parachute, the break cord breaks, separating the static line from the aircraft.

c. Suspension loop - links the parachute and load.

d. Load cover - protects the folded parachute while the load is being moved from loading site to aircraft and during the flight. It is ripped off by deployment of the static line when the load is dropped

e. hamstring - forms the parachute into a hemispherical shape and prevents the air from spilling out around the sides of the 'chute.

ASSEMBLY

a. Tie the break cord to the static line, using a square knot. Fold the static line and set it aside for the moment.

b. Pull the neck drawstring tight, making the neck vent as small as possible. Slide the fiber keeper down to the vent to keep it small. This is now the apex of the parachute.

c. Tie the free end of the static line securely to the poncho's neck drawstring (Figure 1).

d. Suspension lines are next. If you use rope, tie one end of each tent rope to each grommet (metallic eyelet) of the poncho. Tie the other end to the suspension loop, using a double half hitch (Figure 2).

e. Start at one grommet and string the hamstring through it and each succeeding grommet. Return to the starting point and knot the hamstring with a square knot (Figure 3).

f. Tie the suspension loop around the point of suspension on the load using a square knot. If a water or fuel can is the load, loop the loop around all three handles

g. Begin packing the parachute by laying the can, or whatever the cargo, on its side. Pull on the apex vent of the 'chute and lay the parachute out flat. Smooth out the suspension lines. Fold both sides of the parachute in to the center, making it long and narrow.

h. Starting at the suspension loop, S-fold the suspension lines on top of the load and continue the process with the folded 'chute (Figure 4)

i. When the apex vent is reached, secure the parachute and lines in place with one knee, and reach for the load cover.

j. Slit a 1/2-inch hole in the center of the load cover.

k. Insert the break cord through the slit and pull it and the static line through the load cover down to the apex vent.

l. Place the load cover over the parachute and secure it with four to six pieces of masking tape. Then S-fold the static line on top of the cover and secure it with a rubber band or strip of tape (Figure 5).

m. Figure 7 shows an initiated poncho parachute.

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Poncho Parachute
Figure 1

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Poncho Parachute
Figure 2

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Poncho Parachute
Figure 4

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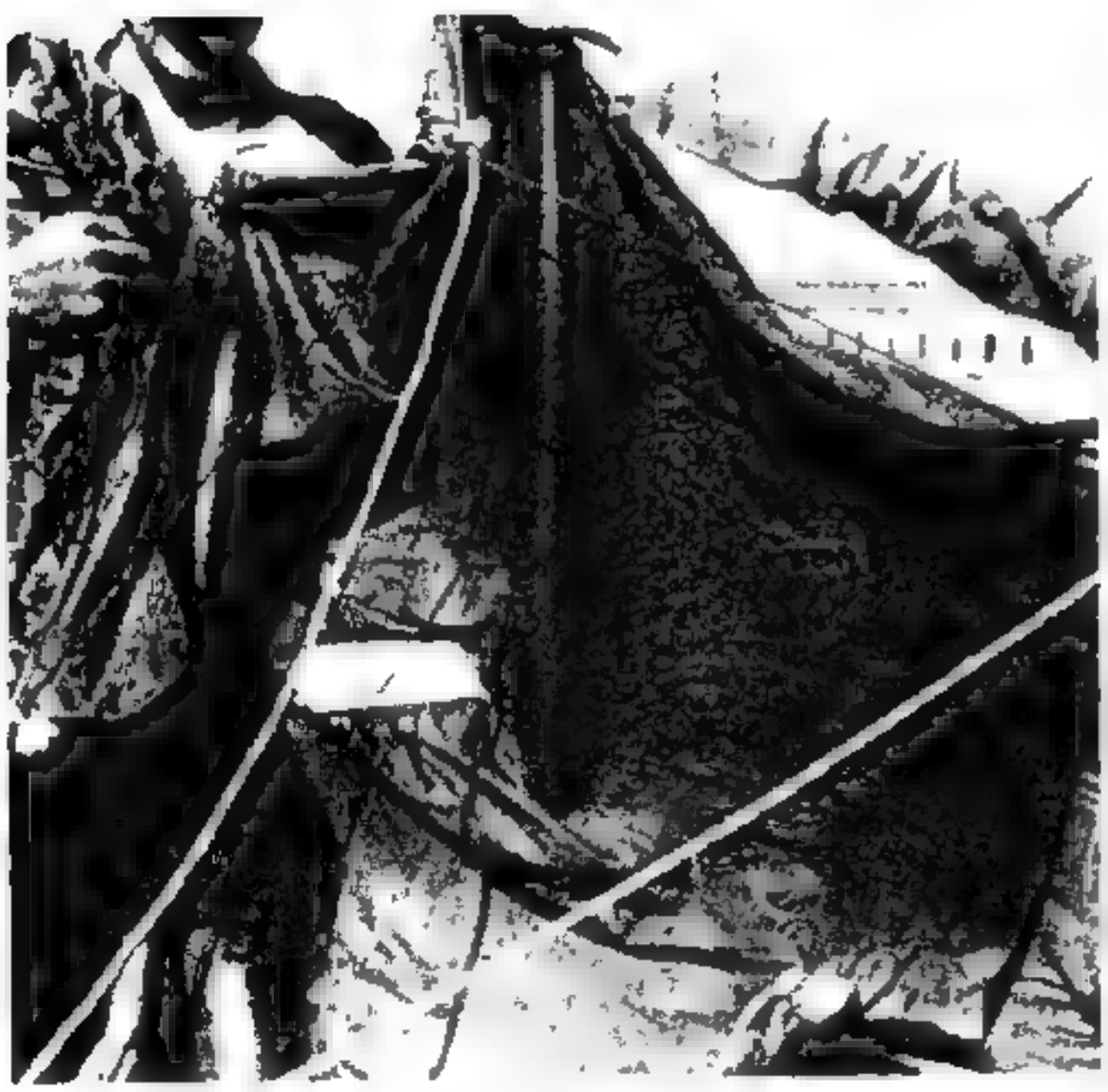

Poncho Parachute
Figure 3

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Poncho Para- hute
Figure 5

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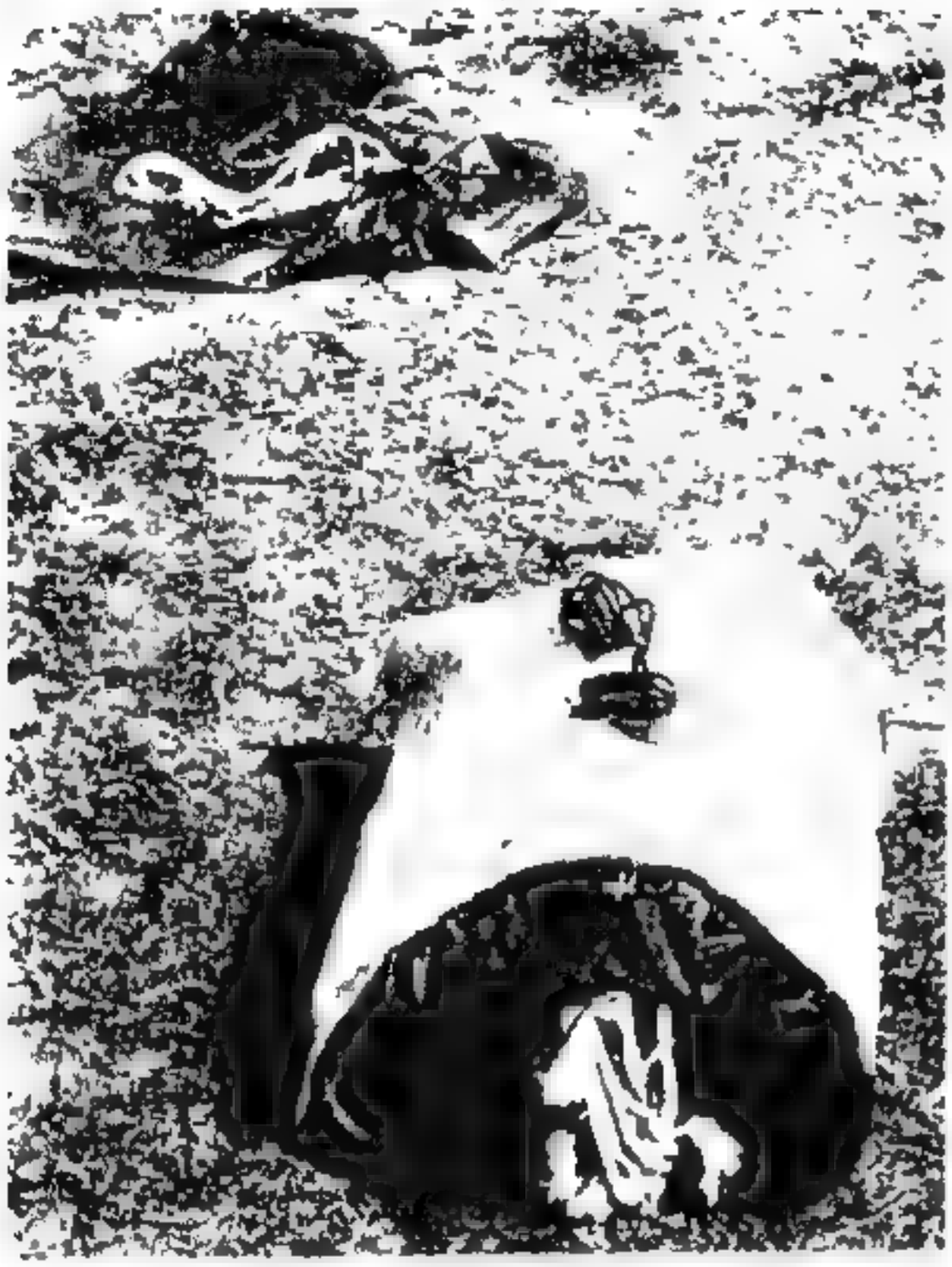

Poncho Parachute
Figure 6

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Poncho Parachute
Figure 7

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V. Direction and Time*

(The information in this chapter was extracted mostly from the author's complete article "True Land Navigation," which appeared in May-June 1964 INFANTRY Magazine, and which in turn was taken from "The Sun Is Your Guide," an appendix to Stackpole Publishing Company's Combat Leaders' Field Guide.)

1. SHADOW-TIP METHOD FOR DIRECTION (FIGURE 1) - This simple method of finding direction by the sun is more accurate than the often-used Watch Method.

a. Place a stick or branch into the ground at a fairly level spot where a distinct shadow will be cast. Mark the shadow tip with a stone, twig, or other means.

b. Wait until the shadow tip moves a few inches. Using a 4-foot stick, about 10 minutes should be sufficient. Mark the new position of the shadow tip in the same way as the first.

c. Draw a straight line through the two marks to obtain an approximate east-west line. If you are uncertain of which is east and which is west, observe this basic rule.

> The sun rises in the east and sets in the west (but rarely due east and due west). The shadow tip moves just the opposite. Therefore, the first shadow tip mark is always in the west direction and the second mark in the east direction, everywhere on earth.

A line drawn at right angles to the east-west line at any point is an approximate north-south line, which will help orient you to any desired direction of travel.

d. Inclining the stick to obtain a more convenient shadow, in size or direction, does not impair the accuracy of the Shadow Tip Method. Thus, a traveler on sloping ground or in highly vegetated terrain need only find a flat dirt spot the size of his hand, because only the shadow tip is marked. The base of the stick can be above, below, or to one side of it.

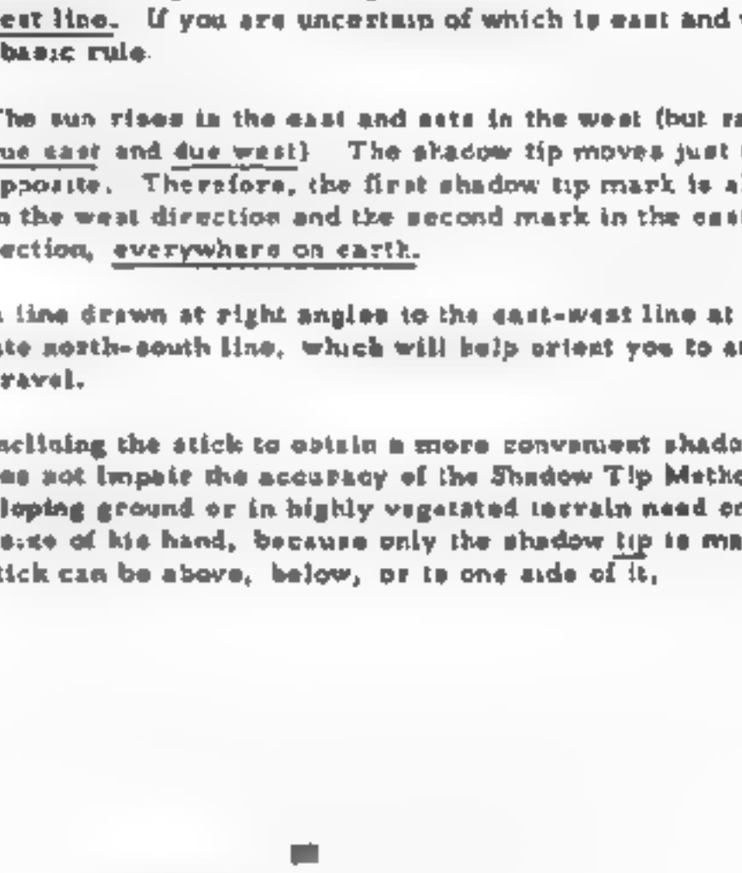

Figure 1

2. SHADOW-TIP METHOD FOR TIME OF DAY (FIGURE 2)

a. Having found direction, move stick to where the east-west line intersects the north-south line, and set it vertically into the ground. The east-west line now becomes the 6 o'clock line. The west part of the line in-

dicates 6 a.m., and the east part is 6 p.m., anywhere on earth, in accordance with the basic rule (par. 1c)

b. The north-south line now becomes the noon line. The shadow of the stick is an hour hand in the shadow-clock and with it you can estimate the

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approximate time (similar to the way you read a 24-hour watch), using the noon line and the 6 o'clock line as your guides. Depending on your location and the season the shadow may move either clockwise or counterclockwise, but this does not alter your manner of reading the shadow-clock.

c. The shadow-clock is not a timepiece in the ordinary sense. It makes every day 12 unequal "hours" long, and always reads 6 a.m. at sunrise and 6 p.m. at sunset However, it does provide a satisfactory means of telling "time" in the absence of properly set watches for such purposes as keeping a rendezvous, estimating the remaining daylight, etc. 12 o'clock shadow-clock time is always true midday, but the spacing of the other hours, compared to regular clock time, varies somewhat with the locality and date.

SHADOW-TIP METHOD
TO FIND TIME OF DAY

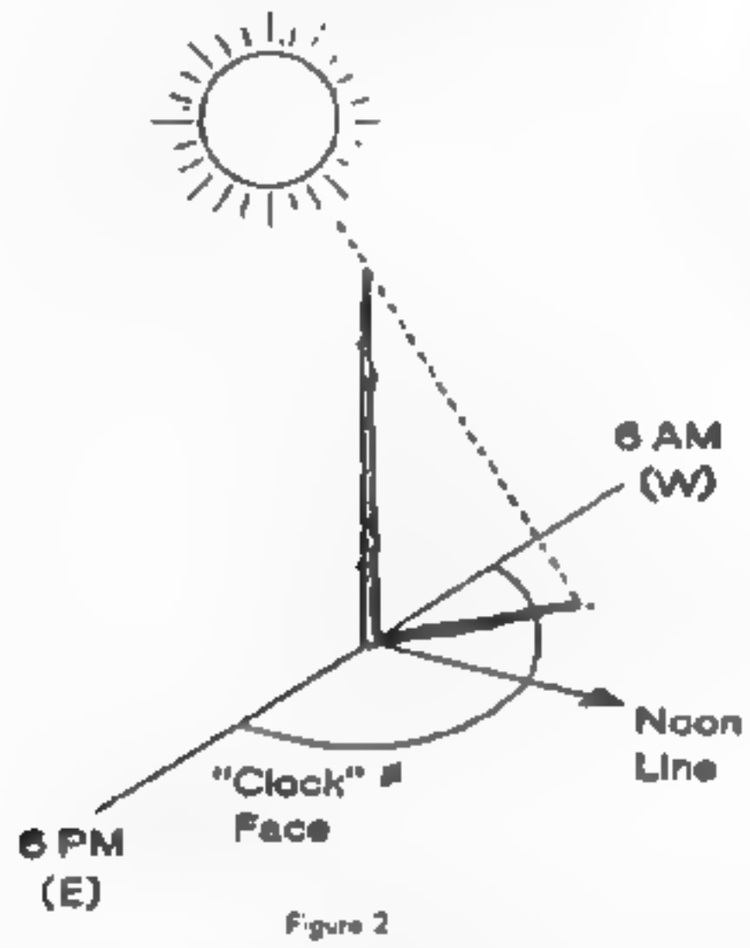

Figure 2

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3. WATCH METHOD (FIGURE 3) - The regular Watch Method, although currently advocated by several Army field manuals and such well known outdoor guides as the Boy Scout Handbook, can be very seriously in error and is therefore generally unreliable and even potentially dangerous

WATCH METHOD

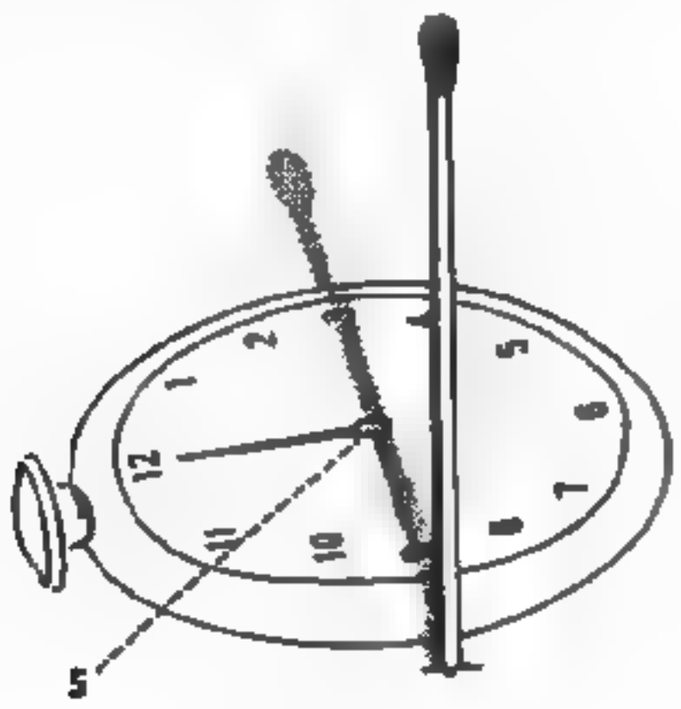

Figure 3

4. OWENDOFF WATCH METHOD - A watch used in conjunction with shadow-clock time (par. 2b) serves to "store up" the direction obtained by the Shadow-Tip Method (par. 1c). Having made a shadow-clock, merely set your watch to the time it indicates. Now proceed as before by pointing the hour hand toward the sun (Figure 3). Your approximate north-south line will lie halfway between the hour hand and 12 o'clock on the dial. Observe the basic rule for shadow-tip movement (par. 1c) when you set the watch to shadow-clock time, and you will never confuse north for south.

This will avoid the 10-minute wait required to complete each subsequent shadow-tip reading for direction, and thereby permit you to take as many instantaneous readings as are needed to avoid "circling." After traveling an hour or so, take a shadow-clock reading and re-set your watch if necessary.

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The direction obtained by the Owendoff Watch Method is the same as that of the regular Shadow-Tip Method by using a stick. That is, the accuracy of both methods is identical.

5. DIRECTIONS AT NIGHT

a. POLE STAR (FIGURE 4) - In the Northern Hemisphere, the North Star (Polaris) is a reliable direction-finder, because it is always nearly true north of the observer. The problem is to locate it. By checking against the pattern shown in Figure 4, first identify the seven stars in the Big Dipper, and then confirm this by finding the five stars in Big "W" (Cassiopeia). Polaris lies about halfway between these star groups, and the two "pointers" aim almost directly at it.

Figure 4

b. OVERHEAD STARS - If the North Star is obscured or cannot be located (or if you are in the Southern Hemisphere), sightings on any overhead star will provide accurate direction. Implant about a 4-foot stick into the ground, inclined somewhat from the vertical. Now lie down on the ground face up, with one eye directly underneath the tip of the stick. Move head slightly until you establish a line of sight to an overhead star, and then remain still to observe the star's direction of movement. Like the sun all stars always move generally from east to west, from which you can orient yourself to any desired direction of travel.

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Note that this procedure is equivalent to taking a Shadow-Tip Method reading (par. 1), the only difference being that you observe the star's movement directly, rather than that of the shadow tip on the ground. The latter is a reflection of the star's movement, with identical results.

As an alternative method, implant the stick vertically. Lying down, sight along the stick with your eye (like a rifle sight) to any overhead star, and observe its direction of movement.

c. MOON - If the moon is bright enough to cast a distinct shadow use the Shadow-Tip Method (par. 1) the same as in daytime to obtain an approximate east-west line. Persons having a watch can make a shadow-clock and use the Owendoff Watch Method (par. 4), which will avoid the 10-minute wait for subsequent readings. However, for time-telling purposes, remember the moon shadow-clock time may be quite different from regular clock time or sun shadow-clock time.

Should the moon be dim, drive an at least 4-foot stick (which may be inclined) into the ground. Lying down, establish a line of sight through the tip of the stick to the moon. Without moving your head, wait a few minutes to observe the moon's direction of movement

As with the sun and stars, the moon always moves generally from east to west.

6. POCKET NAVIGATOR (FIGURE 5) - This is an original device for finding true daytime direction by means of shadow-tip curves. The navigator is intended primarily for troop training in the continental U.S. (48 states), but it will work anywhere around the world at the same latitude band.

a. Place a 1-inch pin vertically at the "cross," and seat it securely. Check by eye to ensure that the pin is truly upright. Press elbows firmly against sides, pull card taut with thumb and forefinger at each end, and face the sun.

b. Close one eye and look straight down at the pin with the other

Keep pinhead just covering the "cross" while you swivel from the hips until the shadow tip just touches the proper month curve. Arrow now points true north. Numbers on the curve show time of day (sun time).

c. Use a. m. half of curve before noon, and p. m. half in afternoon. If not certain whether midday has passed, take a shadow-clock reading, which will unerringly tell you Or, lay the navigator flat on the ground and observe the changing shadow length. If it shortens, it is morning. If it gets longer, it is afternoon.

d. The circles are for practice in getting the card level. Experiment to find particular circle which the shadow tip just follows as you slowly swivel from the hips (keeping one eye on the pinhead as described above). Interpolate between "level circles" if necessary.

e. Where "level circle" touches the month curve is where shadow tip should be when you take a reading. If shadow tip is off card, let the shadow line just touch the very end of the month curve.

f. For "in-between" dates, let the shadow tip touch the 'level circle' at that point between month curves which roughly represents the actual date

g. Keep several pins in your wallet to use with the navigator If you have no pin, use a stick to take shadow-tip readings for direction. The month curve on the navigator is a "map" of your course of travel during the day if frequent shadow-tip readings are taken to maintain direction. For example, if you wish to travel southeast, the "map" will be the same, but it will be elected southeasterly instead of easterly. If you don't have a watch to find out "where you are" on the curve, make a shadow-clock and correct your shadow-tip direction to true direction. (See pages 44 & 45 for navigator)

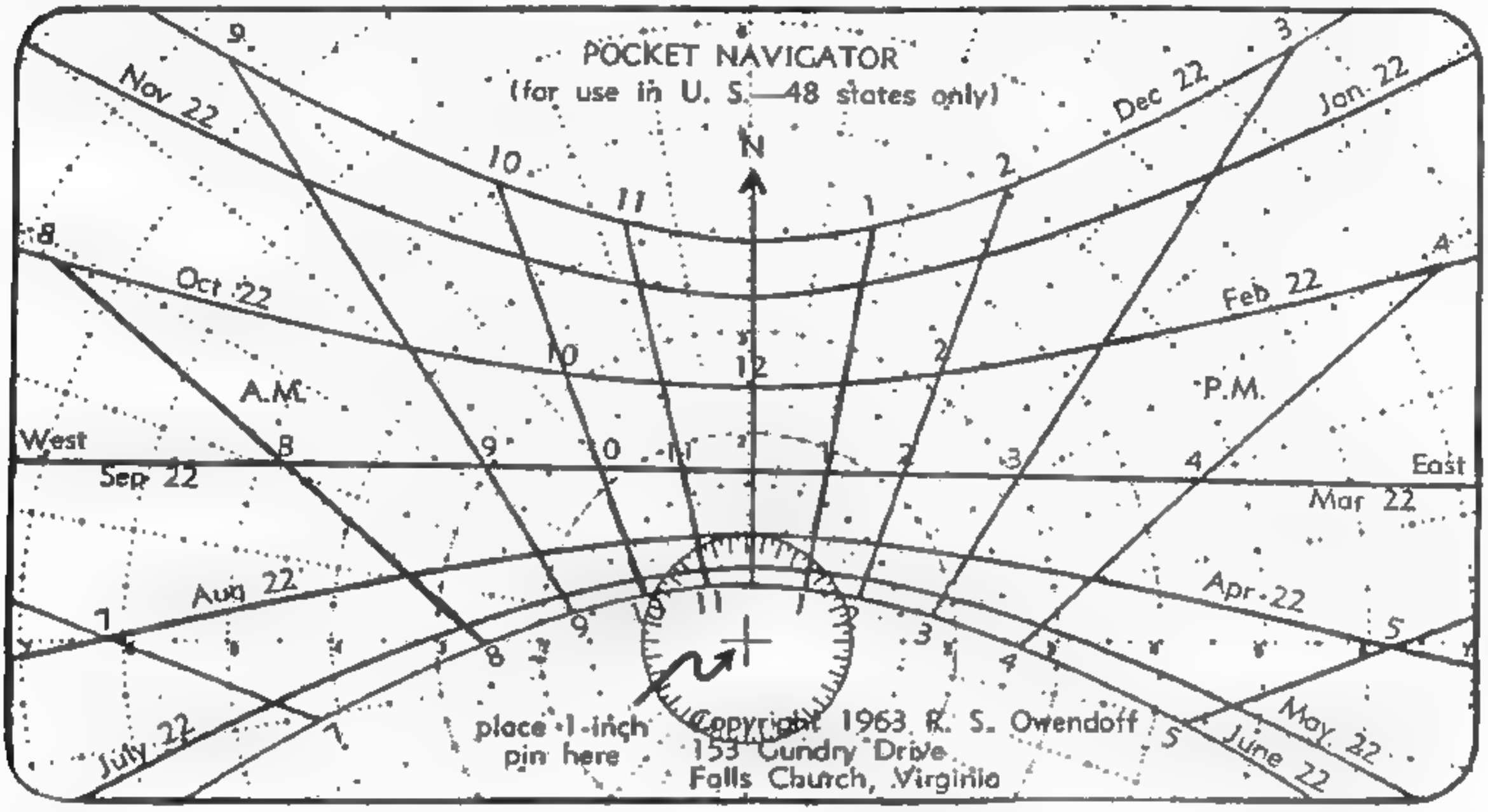

Figure 5.

Bellied Tracked Vehicles

Very often vehicles become high centered on stumps, rocks, dry ridges or in mire. In this position, tracked vehicles are helpless because both tracks are held clear of the ground and cannot get enough traction to move the vehicle. To recover a vehicle bellied on an obstacle attach a log to both tracks at one end of the vehicle If there is no log available, connect the two tow cables of the tank together and, using the towing hooks of the vehicle, attach to both tracks (Figure 1). Then apply power gradually to the tracks; the log or tow cables will strike the obstacle and move the vehicle. Care must be taken to stop the vehicle when the log or cable reaches the rear or front of the tracks, or it will damage the fenders and tow cable. A log should be used in mud.

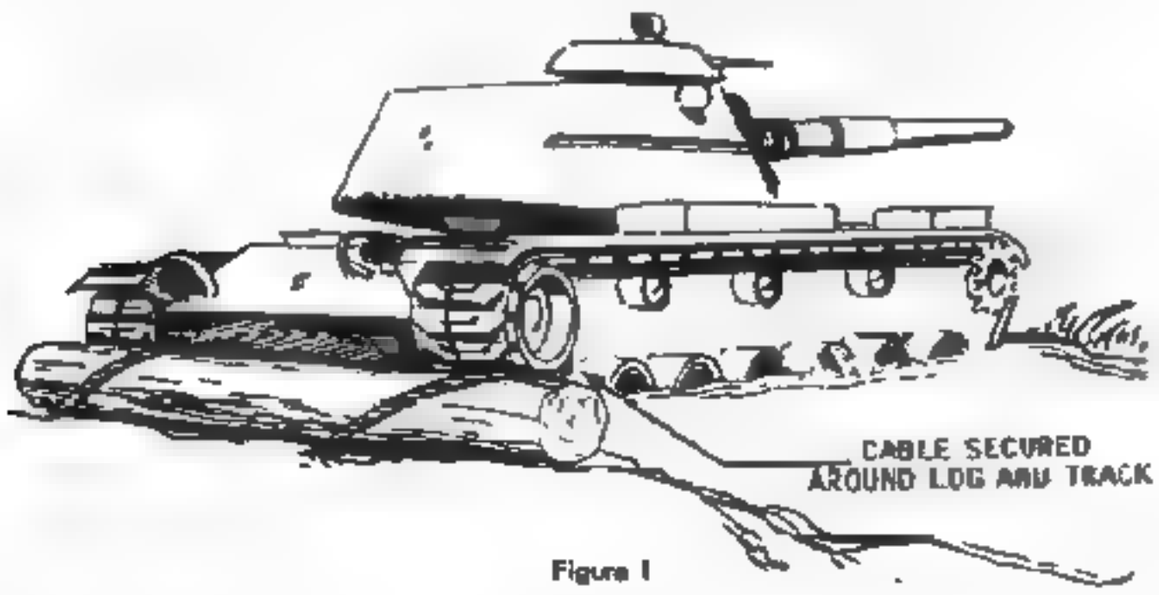

Figure 1

"A" Frame

This expedient provides both lift and tow. To construct an "A" frame, two poles about 8 feet long and large enough in diameter to support the front end of the truck will be needed. The poles should be lashed together at the top by a figure-8 or girth hitch (Figure 2). The lower ends should be placed in the ground 10 to 12 inches deep to prevent them from sliding when power

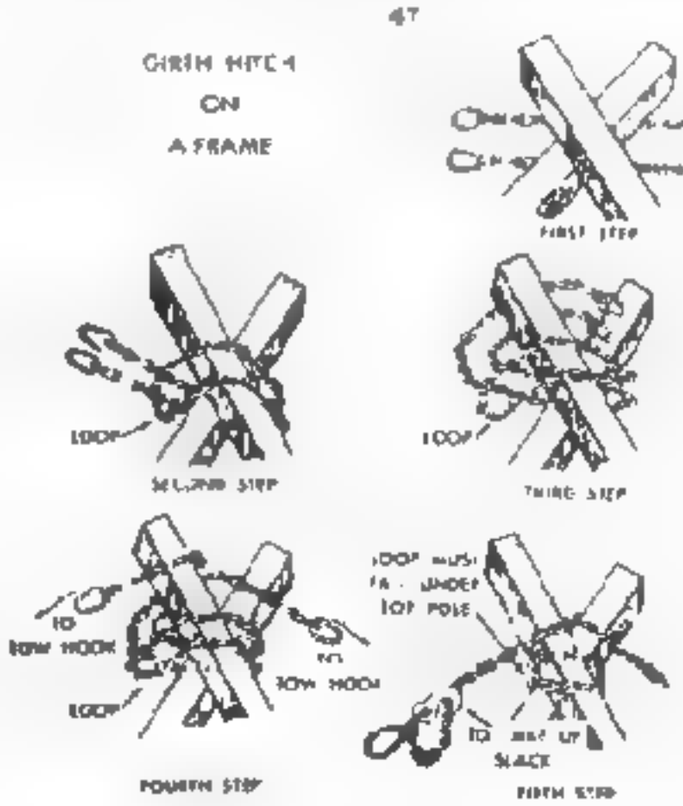

Figure 2

is applied. The upper end of the "A" frame should be laid across the hood of the vehicle and the attachment made as in Figure 3. If the mosed truck is equipped with a winch, the winch cable should be rigged for a 2-to-1 mechanical advantage, with the end of the cable secured to the apex of the "A" frame. If a separate truck is needed because the mosed truck has no winch, a block should be attached to the apex of the "A" frame and a 2-to-1 mechanical advantage rigged from the truck emplaced in front of and alined with the mosed vehicle.

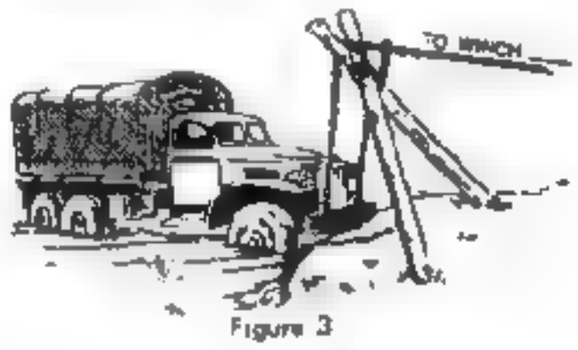

Figure 3

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Skid or "Peg Leg"

A lost or damaged rear wheel on a 4x4 may be replaced by a skid (Figure 4). A green log, about 8 feet long and 5 to 8 inches in diameter, is placed under the rear axle and over the cross member of the frame. The pole should pass under the spring U-bolts, aline with the spring, and be lashed to the spring. The vehicle may be moved by front wheel drive. Distance to be traveled and terrain will determine how many "pegs" will be used.

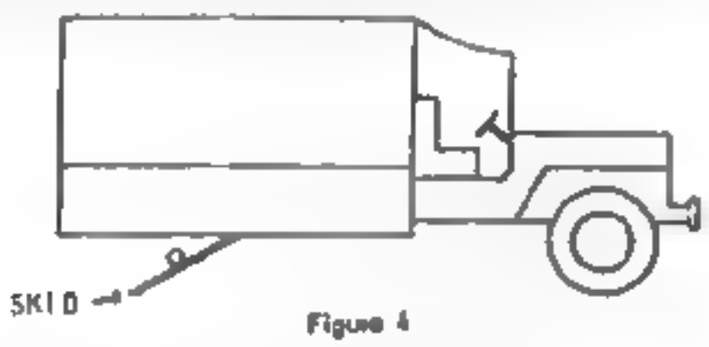

Figure 4

Wheels as a Winch

1. If a wheeled vehicle has no winch, its rear wheels may be used as one. On a dual-wheeled truck, a rope with one end fastened to the wheel hub and the other end anchored can be wound up on the wheel or hub to give the same result as a winch. The end of rope fastened to the wheels should be run between the duals and through one of the holes in the wheel disk. A bowline knot can then be tied in the end of the rope and slipped over the end of the hub (Figure 5). By placing the vehicle in reverse, the rope will wind between the

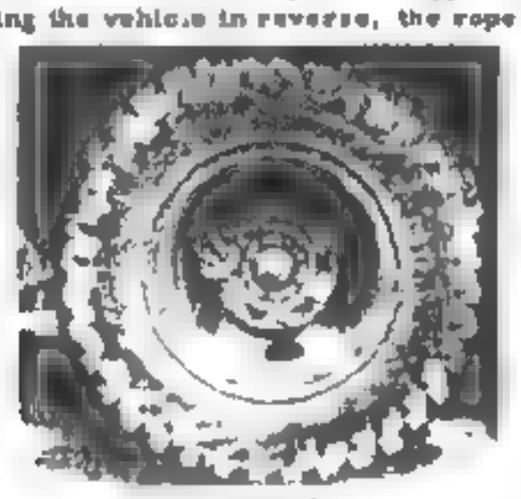

Figure 5

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two duals and the vehicle will move to the rear (Figure 6). Care should be taken to place the rope through a hole in the wheel where the valve stem will not be damaged.

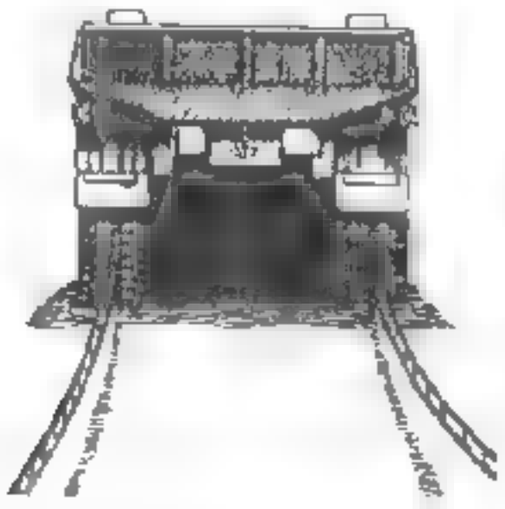

Figure 6

2. If the truck has single wheels, the same system can be used by placing a bar through a hole in the end of the axle flange. The rope can be started by fastening it to the bar with a figure-8 hitch, and the rope will wind in behind the bar (Figure 7).

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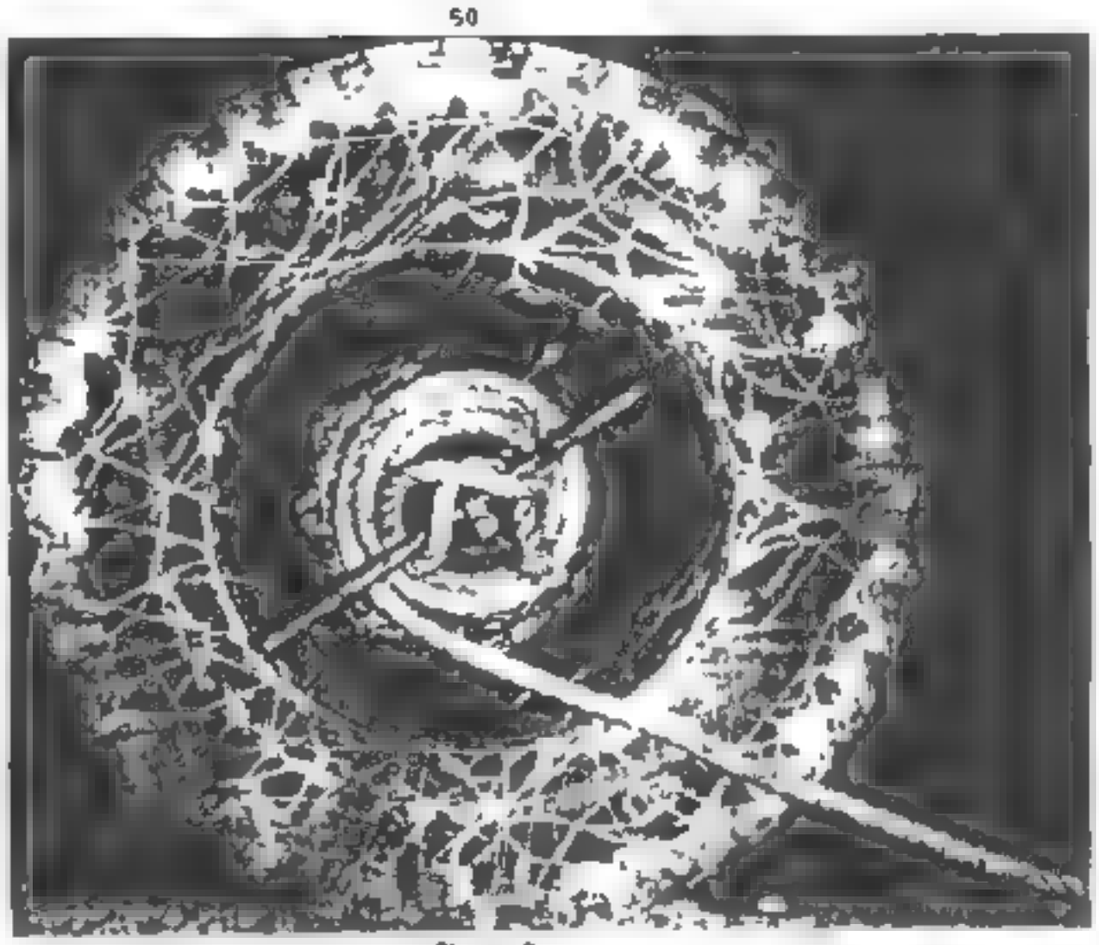

Figure 7

Broken Fan Belt

Replace with rope, a waist belt, or a piece of field telephone wire. The rope should be looped around the pully 3 or 4 times and tied with a square knot.

Vapor Lock

The fuel pump will not pump vapor. This malfunction is common in hot climates or when the engine operating temperature becomes too high. Wrap the fuel pump with a piece of burlap or other cloth that has been soaked in water. This will lower the fuel temperature enough to keep the fuel in a liquid state. Cold water alone may be used when cloth is unavailable.

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Frozen Fuel Line

These may be thawed by connecting wire leads to each end of the fuel line and running current through the line. The line will heat and melt the ice. Do not arc the wire against the line. Attach wires securely to fuel line first, and then connect them firmly but momentarily at the battery.

Broken Fuel or Oil Line

Such broken lines under low pressures or vacuum may be spliced temporarily by forcing a piece of hose over the broken ends of the line. A piece of hose cut from the windshield wiper may be used.

Dirty Ignition Points

If you have dirty points, the distributor cap, rotor, or magneto cover may be removed and the breaker points cleaned with the striking area of a match book cover. The match book cover can be used to check the point opening or clearance.

Broken Brake Line

Crimping a cut brake line will allow the brakes on the remaining wheels of a vehicle to continue functioning without the loss of brake fluid.

Cracked Distributor Cap

Cracked caps have a tendency to fill with moisture. Sparks, running along the moisture, cause some burning which creates carbon. Scrape a notch in the cap, or rotor, deep enough to remove all carbon from the crack, then fill the crack with tar from the top of the battery.

Loose Battery Terminal

If a battery terminal cannot be tightened, insert a wood or metal wedge between the terminal and terminal post to tighten as much as possible.

Broken Spring Leaves

Broken leaves may be splinted in place with strong pieces of wood or tightly wrapped in place with wire. One, or several, tent pins may be used as splints. If necessary, prevent axle displacement by fastening wire around the front spring hangar and axle. Repair as soon as possible.

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Mobile Command Posts

1. (See Figures 8-10) The upright supporting frame of the device may be removed and strapped to the back of the jeep in the same manner as the

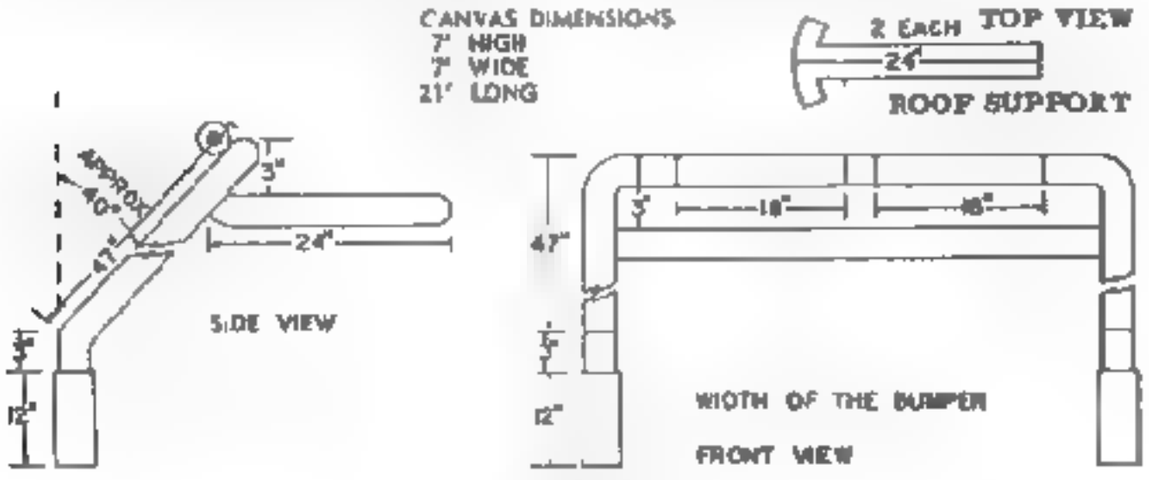

Figure 8

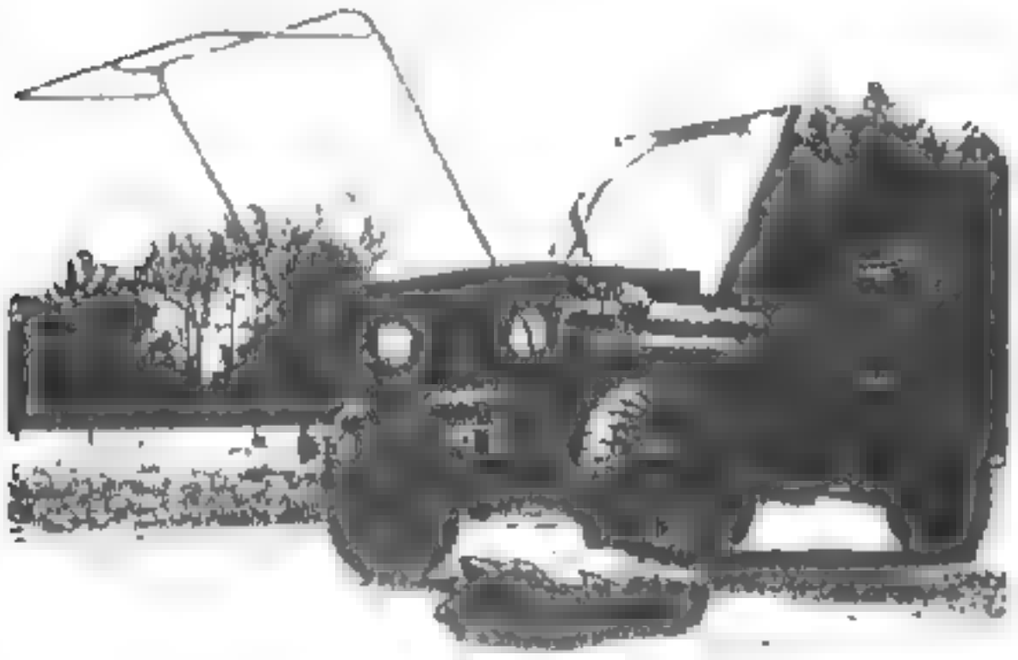

Figure 9

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top is carried. When canvas is thrown over the framework, CP is ready for use. Lights and heat are supplied by the jeep. The enclosed area is large enough to accommodate communications equipment and a map board.

Figure 10

2. (See Figures 11 and 12) A canvas cover to cover a jeep completely was made and zippers installed to allow easy access to the inside of the jeep. A jeep headlight was suspended in the center of the vehicle with a line connecting it to the battery as a power source. There is plenty of room in back for a radio operator and his equipment and in front for a staff officer and his map. Brackets were welded to the side of the jeep to carry extensions of the radio antenna. A pole, hinged onto the rear bracket, provides support for the erection of the antenna.

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Figure 11

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Figure 12

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VII. Blast Devices

Flame Fougasse (Figure 1)

1. DESCRIPTION. The flame fougasse is a variation of the exploding flame device in which the flame is projected by explosive means in a predetermined direction over a preselected area. It is a 1-shot expedient which can be used effectively in the defense. The flame fougasse consists of an empty 8-inch howitzer propelling charge or similar container, filled with thickened fuel and equipped with an explosive charge (propellant), a wood disc (piston), and a white phosphorus grenade (igniter). Flame fougasses can be emplaced along barbed wire, where the nature of the terrain does not permit barbed wire obstacles to be covered effectively with flanking fires.

2. ASSEMBLY.

a. The flame fougasse should be assembled in a vertical position. A 1/4-pound piece of composition C-3 explosive is formed around an electric blasting cap and placed in the bottom of the container. Black powder may be substituted for the explosive and grenade igniter. If powder is used as the propellant, squibs are preferred in place of blasting caps. Wires from the electric blasting cap are brought out of the case through a small hole punched in the side of the case near the top rim.

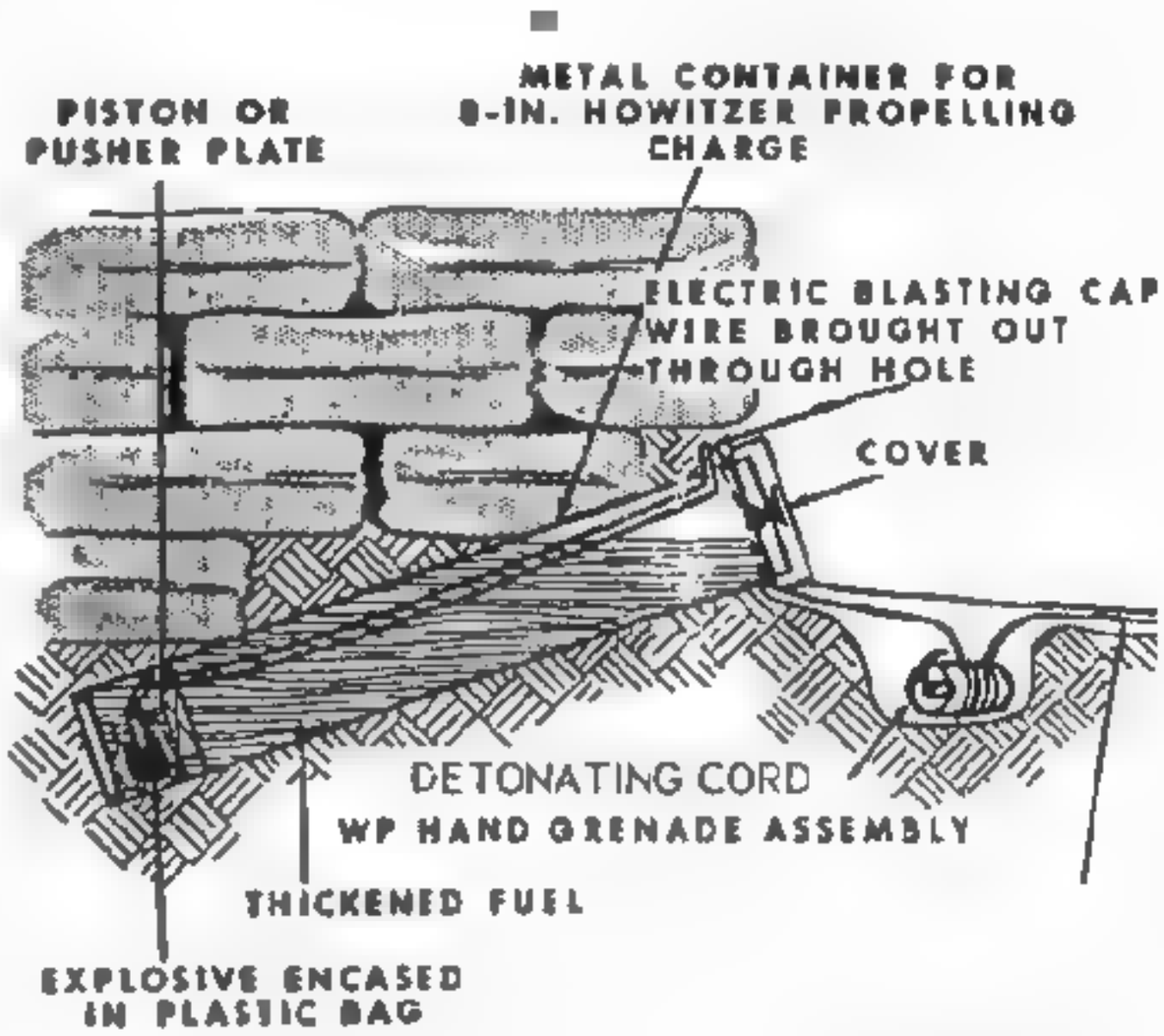
b. A wood disc approximately 2 inches thick and 8 inches in diameter (1/4 inch less than the inside diameter of the container) is placed in the container. The disc should fit into the container easily with approximately a 1/8-inch clearance and should lie flat in the bottom of the container and rest on top of the explosive and blasting cap.

c. The case is filled with a 5 percent thickened fuel mixture (approximately 5 gallons).

d. The metal cap is replaced on the container. The rubber gasket should be on the cap and should be seated firmly to prevent thickened fuel from spilling. The spider of the cap is engaged in the slots for transporting only.

e. The detonating cord-WP hand grenade assembly is prepared by taping or tying the fuse handle tightly to the body of the grenade; spread the tips of the grenade cotter pin sufficiently to ensure that the cotter pin will not work free, wrap five turns of the detonating cord around the body of the grenade and secure with a clove hitch. Attach an electric or nonelectric blasting cap to one end of the detonating cord. Sympathetic detonation from the detonating cord will activate the grenade booster thereby producing the desired ignition.

3. RANGE. Range will be determined by the degree of slope of the emplacement, amount of explosive used, thickness of fuel, and wind direction. The flame will be projected under optimum conditions over an area 50 meters long by 10 meters wide.



Flame fougasse.

Figure 1

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Exploding Flame Device (Figure 2)

1. DESCRIPTION. Exploding flame device consists of a container (5 to 55-gallon), an incendiary fuel (usually thickened gasoline), a firing system to scatter and ignite the fuel. The size of the area covered will depend upon the size of the device. There is no standard type exploding device and many different types were made during the Korean conflict. Maximum effect is obtained when the exploding flame device is exploded above ground. The placement of the container depends upon the container being used. For example, a 5-gallon container gives maximum effect when placed upright with explosive inserted or taped tightly to the top of the container; the 55-gallon drum should be placed on its side.

2. ASSEMBLY

a. Fill container with thickened fuel and seal.

b. Tape the explosive tightly to the container. The explosive should be prepared as shown in Chapter 4, FM 5-25.

c. Prepare a detonating cord-WP hand grenade assembly (see flame fougasse) to ignite the fuel.

d. Attach electric wiring or detonating cord so that the weapon may be fired individually or in multiple form.

e. A safe distance should be maintained between the firing point and the area of detonation.

f. Devices may also be fired by fusing mechanisms attached to permit either individual or multiple detonations by trip wire release, pressure release, or other means.

3. RANGE. Casualty-producing effects resulting from the explosion of the flame devices are obtained by fragmentation of the steel drum and by burning blobs of thickened fuel. Radius of dispersion and particle size varies with the container being used, gage of steel, thickened fuel, and the amount of explosive used.

Flame Illuminator (Figure 3)

1. DESCRIPTION. The flame illuminator is a field expedient effective for limited illumination of selected areas of the battlefield. It consists of a container (5- to 55-gallon) filled with thickened fuel to within 3 inches of the top, a WP hand grenade to ignite the fuel, an explosive charge, and a firing system. Burning time is affected by many factors, including viscosity of the thickened fuel, size and shape of the container, and size of the opening. A thick fuel burns longer than a thin fuel. A narrow container functions longer than a wide container. For example, the burning time for a flame illuminator made from an 8-inch howitzer propelling charge container filled with a 4 percent thickened fuel can vary from 2 to 8 hours depending upon the restriction of the size of the opening.

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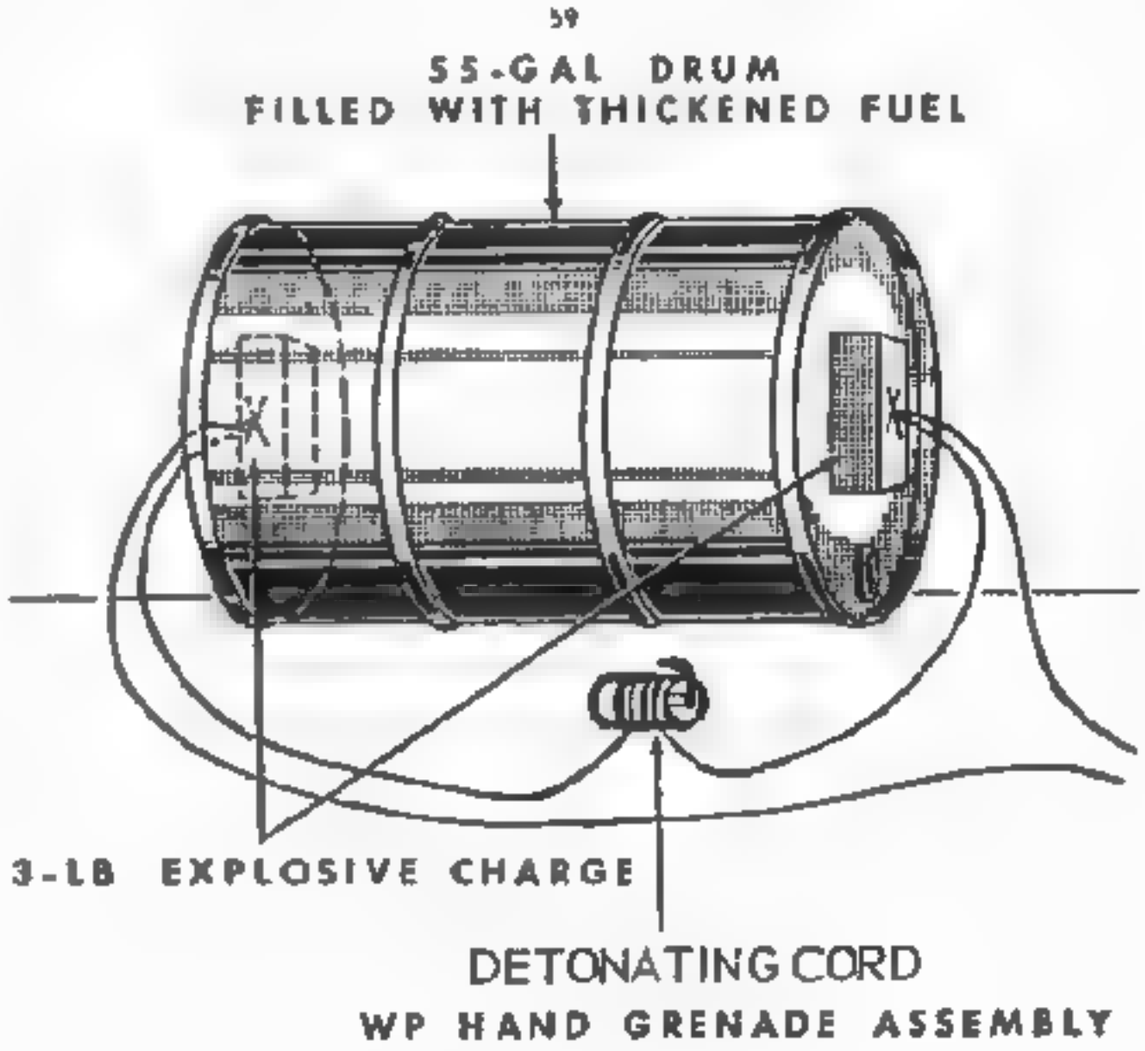

Figure 2

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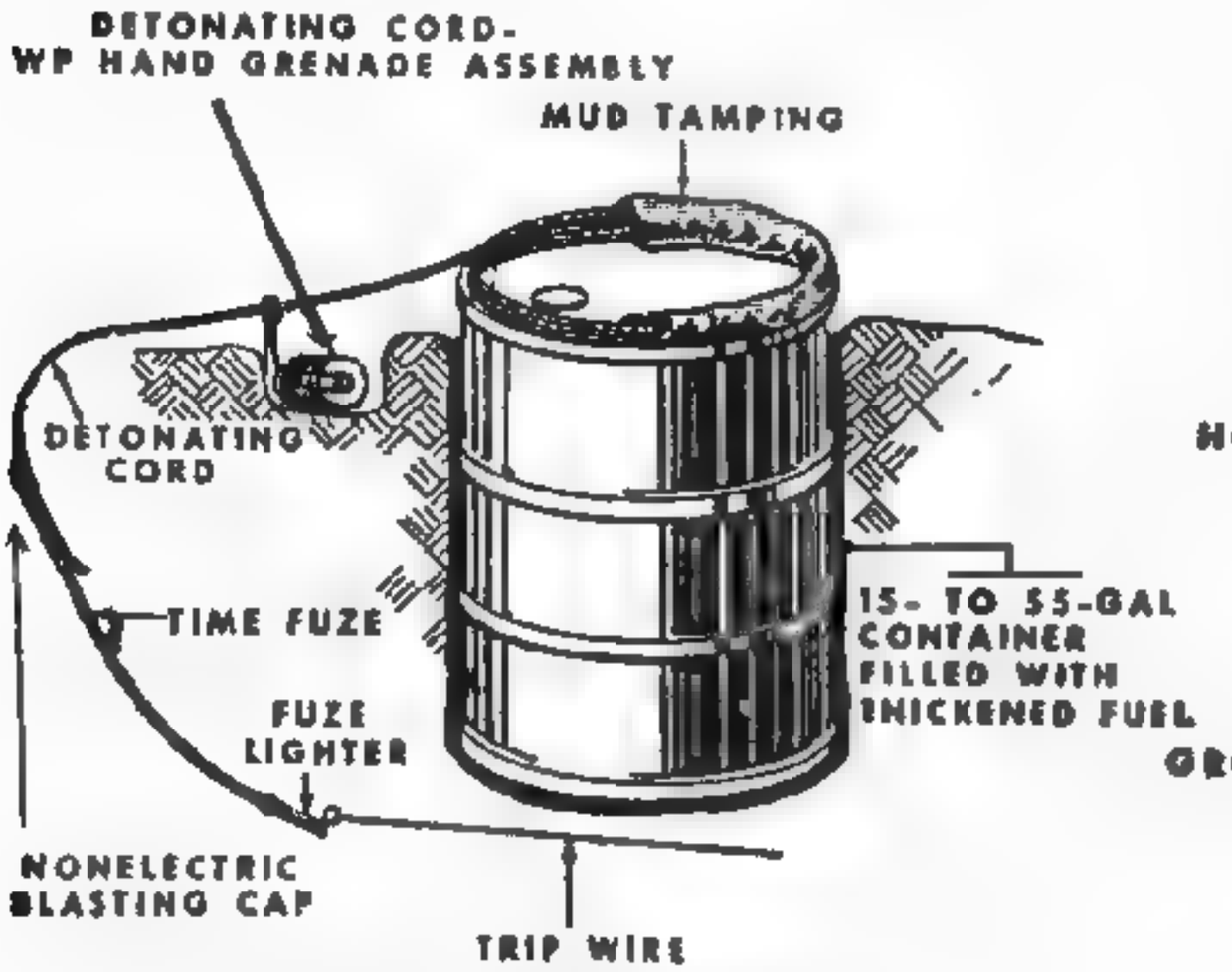

Type napalm illuminator with nonelectric firing system.

Figure 3

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2. ASSEMBLY

a. General. Fill the container with thickened fuel and seal it tightly.

b. For electrical firing

(1) Wrap three turns of the detonating cord on top of the container along the inside of the top rim. Pack moist earth or mud against the detonating cords. (This packing holds the detonating cord in place and acts as a tamper.) Attach an electric blasting cap to one end of the detonating cord.

(2) Prepare a detonating cord-WP hand grenade assembly (see example in flame fougasse) and attach it to the top of the container or in a small hole nearby in such a manner that the functioning of the explosive charge and the grenade assembly will be simultaneous, thereby igniting the fuel

(3) Connect the lead wires from the electric blasting cap assembly and tape the blasting cap to the detonating cord. Emplace the igniter

3. EFFECTS. The flame illuminator burns with a bright flame 1-1 1/2 meters high illuminating an area about 50 meters in diameter.

Husch Flare (Figure 4)

1. DESCRIPTION. The Husch flare is a specific type of flame illuminator that permits thickened fuel to be vaporized and expelled as a burning jet through a small hole It consists of one or more metal cylindrical tubes, such as propellant or shell containers, filled with thickened fuel and inverted into a larger metal container also containing varying amounts of thickened fuel. The illustration shows an example of a Husch flare consisting of a metal container, two 81mm mortar round metal containers, thickened fuel, and an illuminating hand grenade. Assembly details listed below relate to a Husch flare consisting of these components, however, Husch flares can be constructed by using other similar components

2 ASSEMBLY

a. Remove any metal crossbars from the inside of the metal container. Punch three 1/8-inch holes in each side approximately half way between the top and bottom. Fill the container 1/3 full of thickened fuel.

b. Punch a hole no larger than 1/8-inch in the bottom of the 81mm mortar metal container.

c. Temporarily stop holes and fill the containers approximately 3/4's full of thickened fuel, apply heavy grease to the mortar container caps and fasten the caps on tightly to make the mortar shell containers leakproof.

d. Place the 81mm morter round metal containers in the larger metal container with caps down. Use large stones in the latter to wedge the smaller containers firmly in plate and upright. Remove temporary stop from the holes in the 81mm round containers

e. Tie an illuminating hand grenade between the 81mm mortar round containers just above the top leve. of the outside metal container

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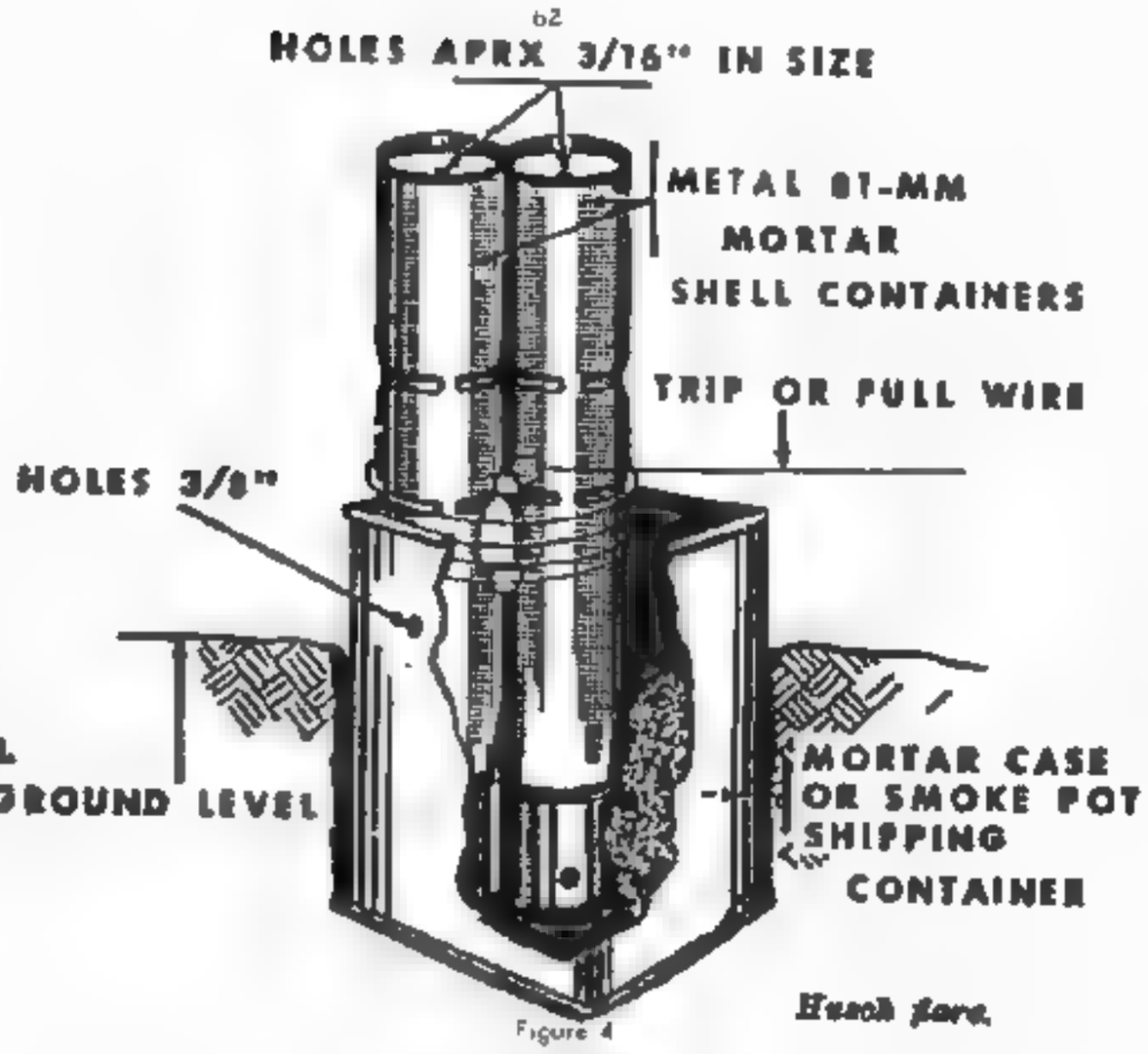


Husch flare.

Figure 4

6.

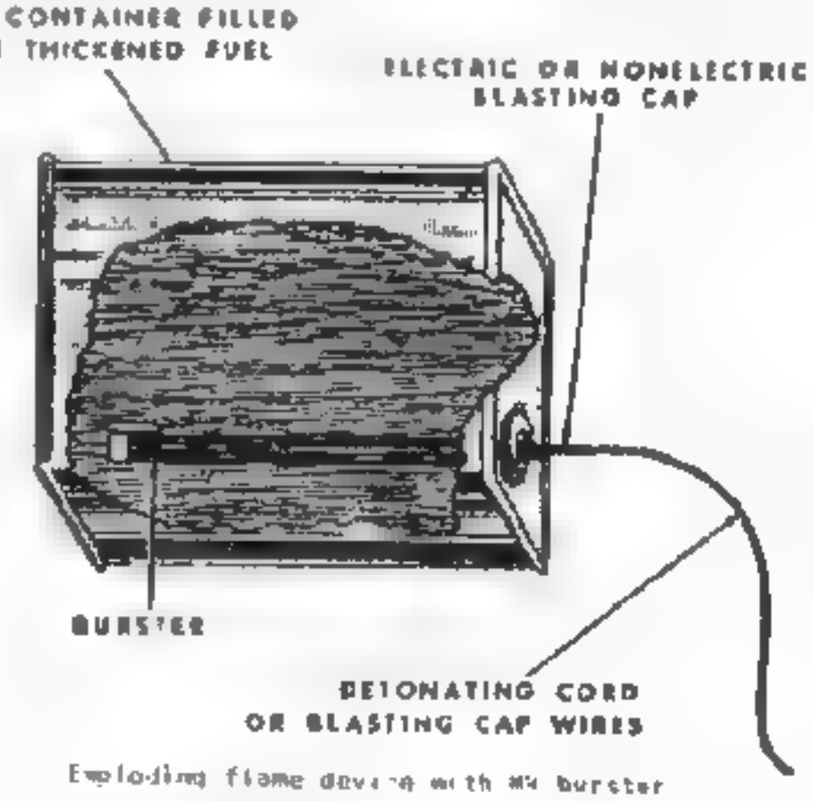
f. Attach a suitable length of pull or trip wire to the pull ring of the grenade. Lead pull wire to point selected for activation (at least 25 meters from the device when normally operated)

g. Press the tips of the grenade cotter pin together so that it can be released easily.

3. EFFECTS. When ignited, this particular Husch flare burns for approximately 90 minutes, illuminating an area up to 50 meters in diameter.

Exploding Flame Device with M4 Burster (Figure 5)

1. DESCRIPTION. This is a specific type expedient which consists of a 5-gallon lubricating oil can or similar type container filled with thickened fuel, a burster, a leakproof metal well, and an initiating device, either electric or nonelectric. The burster and metal well must be fabricated by a unit which has the facilities for procuring and working the necessary materials.



Exploding flame device with M4 burster

Figure 5

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2. FABRICATION OF BURSTER AND BURSTER WELL.

a. The burster well is made of thin sheetmetal and is of a diameter that will fit within the can opening. It has a right angle flange on the open end, which keeps it from slipping entirely within the can and helps to form a seal. The length of the burster well should be approximately 1-inch less than the depth of the can with which it is used.

b. The burster, consisting of the components listed below, is contained in a cylindrical cardboard container closed at one end and of a diameter that will permit it to fit within the burster well. It should be approximately 1/8 inch shorter than the burster well) The cardboard container is filled with--

(1) 75 grams of an equal mixture of black powder and magnesium.

(2) 24 inches of detonating cord, folded evenly and longitudinally.

(3) A wood shipping plug, inserted in the burster well to provide an interior well for a blasting cap. At assembly, this shipping plug is re-

moved and a blasting cap is inserted.

3. ASSEMBLY.

a. Drill or punch a hole in the cap of the container large enough to accommodate the base cap of a pull-type firing device. Unscrew the base cap from the main body of the firing device. Discard the plastic cap and insert a nonelectric blasting cap in its place. Insert this assembly through the bottom of the container can and screw it to the main body of the firing device. Fill the container with thickened fuel. Insert the burster well and then the burster, after shipping plug is removed. Screw the cap assembly tightly onto the container. Attach pull wire.

b. The weapon can be detonated electrically by substituting an electric blasting cap, field wire and a source of current for the pull-type firing device and nonelectric blasting cap.

4. RANGE. When detonated, this flame device scatters burning fuel over an area 30 meters in diameter.

The Platter (Figure 6)

This is a shaped charge using a flower pot and a platter big enough to cover the open top of it. When filled with explosive (preferably C-4) and detonated, it can be effective up to 50 feet away. Other containers and plates may be used. The fuse must be placed in the exact center of the explosive, the charge face must be concave, and the explosive must be packed tightly against the end of the container. With standoff equal to the diameter of the container, this charge may be used to penetrate armor plate. To determine the amount of explosive, use this guide:

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DIAMETER OF CONTAINER	POUNDS OF EXPLOSIVE
less than 2"	1/2
2-5"	1
More than 5"	2-2 1/2

To use as an antipersonnel weapon, fill the empty space in the container with scrap metal and aim it down an expected enemy approach. The resultant fan will be about 50 meters wide and extend about 50 meters to the front.

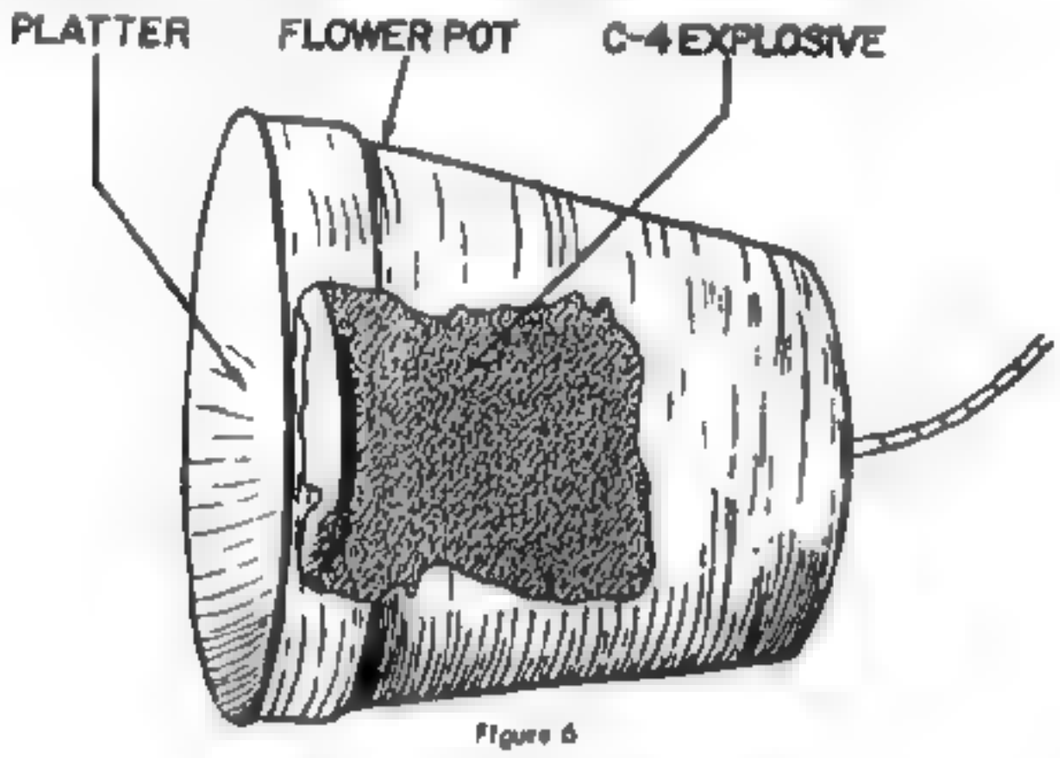

Figure 6

Machine Wrecker (Diamond Charge)

Machinery may be made inoperative by shearing its drive shaft. To make the diamond charge (Figure 7), cut a piece of tinfoil, paper, or burlap into a diamond shape, with the long axis several inches longer than the circumference of the shaft to be sheared. The short axis should be about 1/2 the length of the long axis. Mold a plastic explosive over the diamond and place blasting caps into the explosive at the short axis points. To cut regular steel, the explosive should be about 1/4-inch thick; for high carbon steel,

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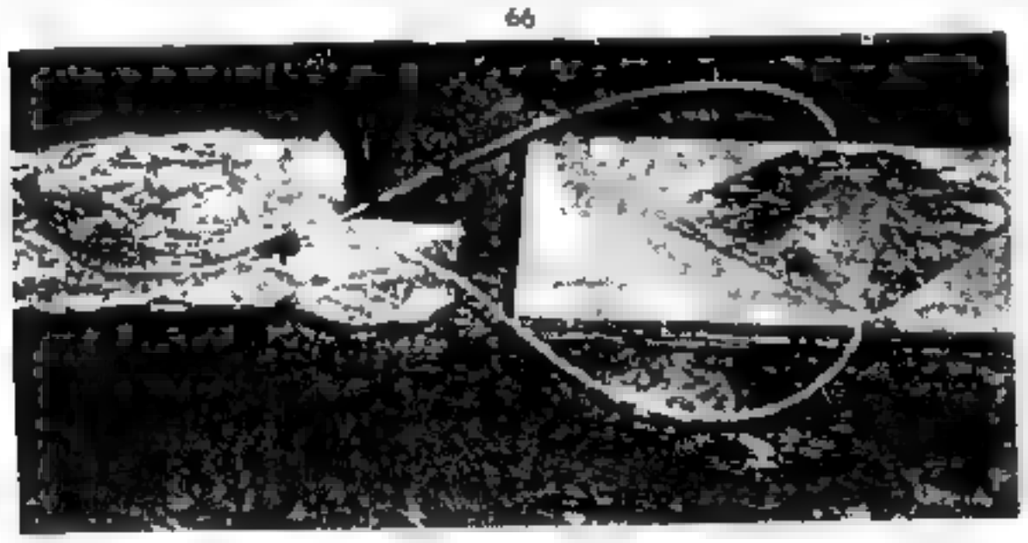

Figure 7

3/4 inch thick. Emplace the charge by wrapping the long ends of the diamond around the shaft. Ensure that the two pieces of detonating cord used with the two blasting caps are equal and detonated from a common source (Figure 8).

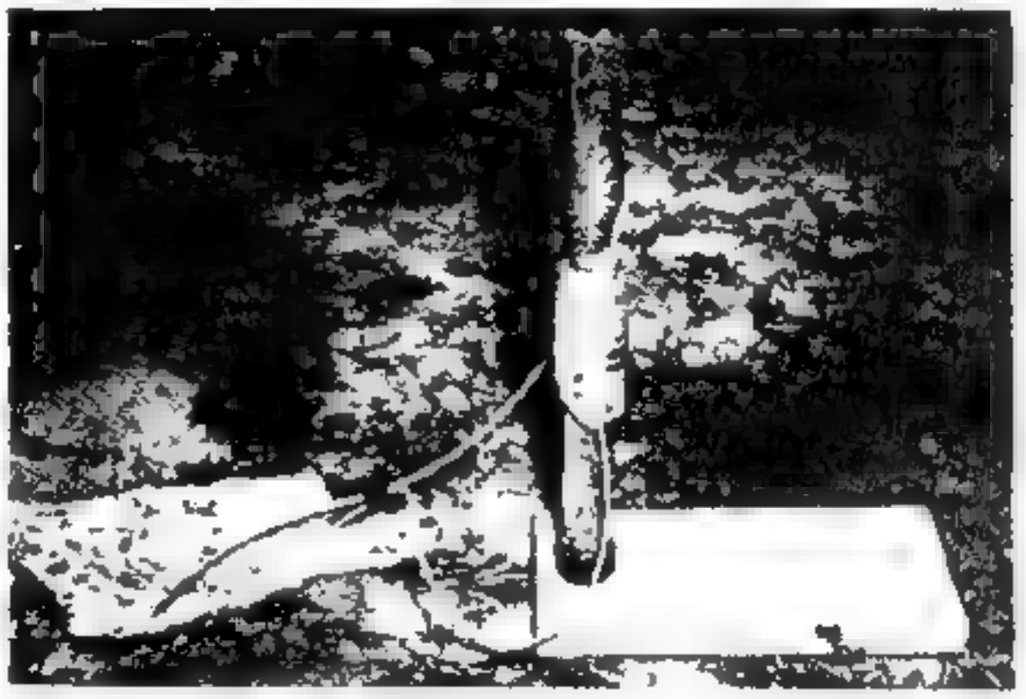

Figure 8

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Molotov Cocktail

Mix one-half motor oil and one-half gasoline in a well-stoppered bottle. Gas-soaked rags or waste should be taped to the bottom of the bottle. Light the waste and throw it at the engine compartment of an armored vehicle. The burning gas and oil may ignite the engine compartment and possibly cause the tank's ammo to explode.

Improvised Grenades

1. By packing a C-ration can with composition C-3 with 45-50 ammo rounds imbedded at random in it, a passable expedient grenade may be made. A time fuse (attached to a blasting cap in the C-3) and matches complete the grenade.

2. C-4 can be molded around a blasting cap and fuze. By sticking nails and other metal into the C-4, another expedient grenade can be made. A fuse lighter completes the grenade.

Satchel Charge AT Expedient

A satchel charge made out of TNT and at least 10 pounds of C-3, C-4 or C-5 can be placed in or on the engine compartment of a tank, under the turret ring or jammed behind a drive sprocket to destroy or damage an enemy armored vehicle.

3.5" RL Mine

A 3.5" rocket launcher round in a carton in the ground pointed at the place where the belly of a tank will be can be an effective AT device when batteries are connected to the terminals on the 3.5" round to detonate the round.

The "Ear Muff" (Figure 9)

1. This is good for destroying concrete piers on bridges or docks. The technique is based on the counterforce theory. Use a pound of C-3 or C-4 for each foot of concrete to be breached. If it's reinforced concrete, use 1 1/2 pounds per foot. Emplace the charges as follows:

a. Obtain containers of sufficient size to hold the composition C. Tin cans, plastic drinking cups or buckets may be used. It is important that each pair of containers be exactly the same size and type.

b. Make a hole in the exact center of the bottom (closed) end of the container so that the blasting cap may be inserted there.

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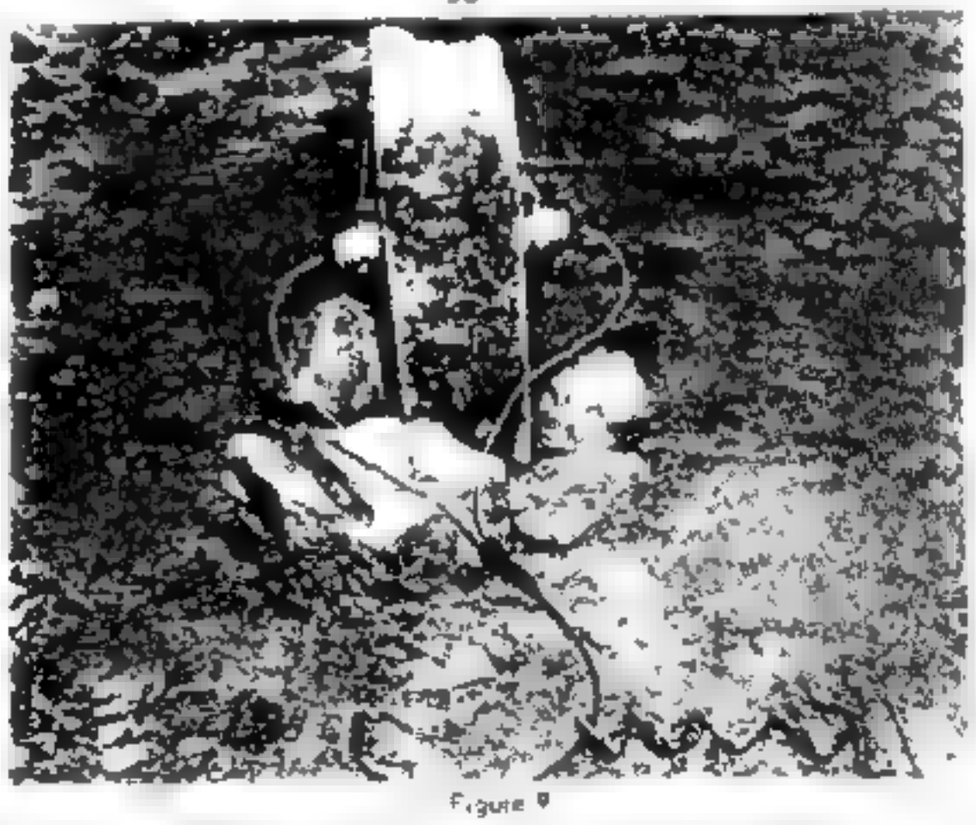

Figure 9

c. Place the composition C in the containers, making sure it is molded to the bottom.

d. Stick the sharp end of the handle of the cap crimpers into the hole at the bottom of the container, making an indentation in the composition C which allows the blasting cap to be inserted 1/4 inch.

e. Measuring off two pieces of detonating cord exactly equal in length, crimp a blasting cap to one end of each.

f. Place the blasting caps, with the detonating cord attached, into the holes in the bottom of the composition C containers and secure them in place with tape or string.

g. Then attach the other ends of the two short, equal pieces of detonating cord to a third blasting cap, time fuse and fuse lighter.

h. Place the two containers exactly opposite each other on the object to be destroyed, holding them in place with rope, string or other materials.

i. Detonate the charge using standard demolition techniques.

VIII. Training Aids

1. LUMINOUS NOTEBOOK (Figure 1) - Distances, directions, call signs and checkpoints can be quickly scribbled on the acetate with grease pencil which can be easily seen at night against the glow of the luminous paper. A quick sweep will erase the notes completely against possible compromise. Patrol leaders may find such notebooks handy for flashing prearranged signals in the dark.

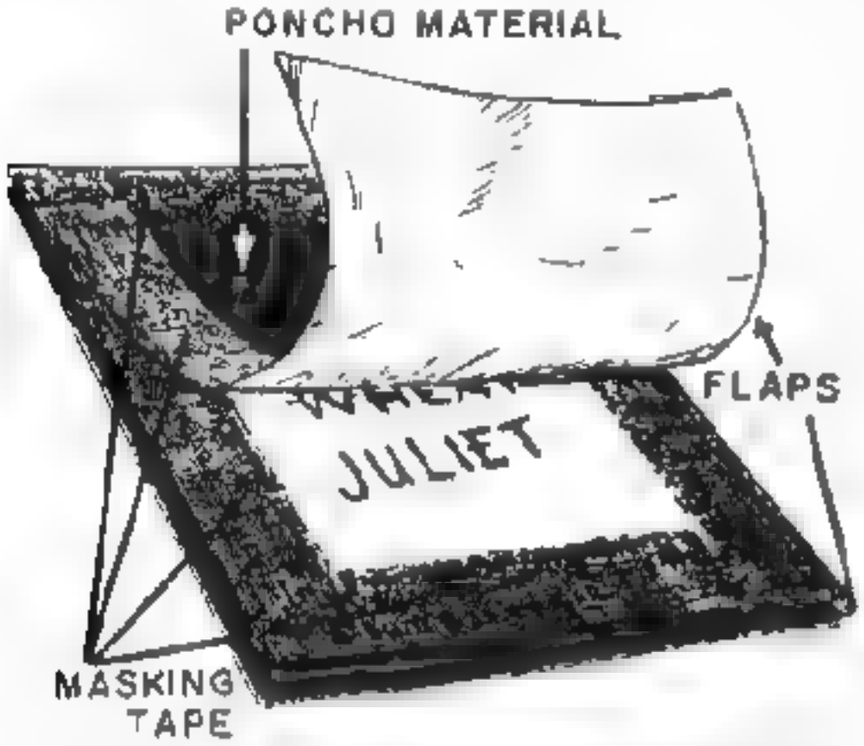

Figure 1

2. DAGWOOD BOARD (Figure 2) - Rapid production of multiple copies of operation orders, overlays, and similar data is difficult without reproducing machinery. To prepare an overlay with the Dagwood board, place a map

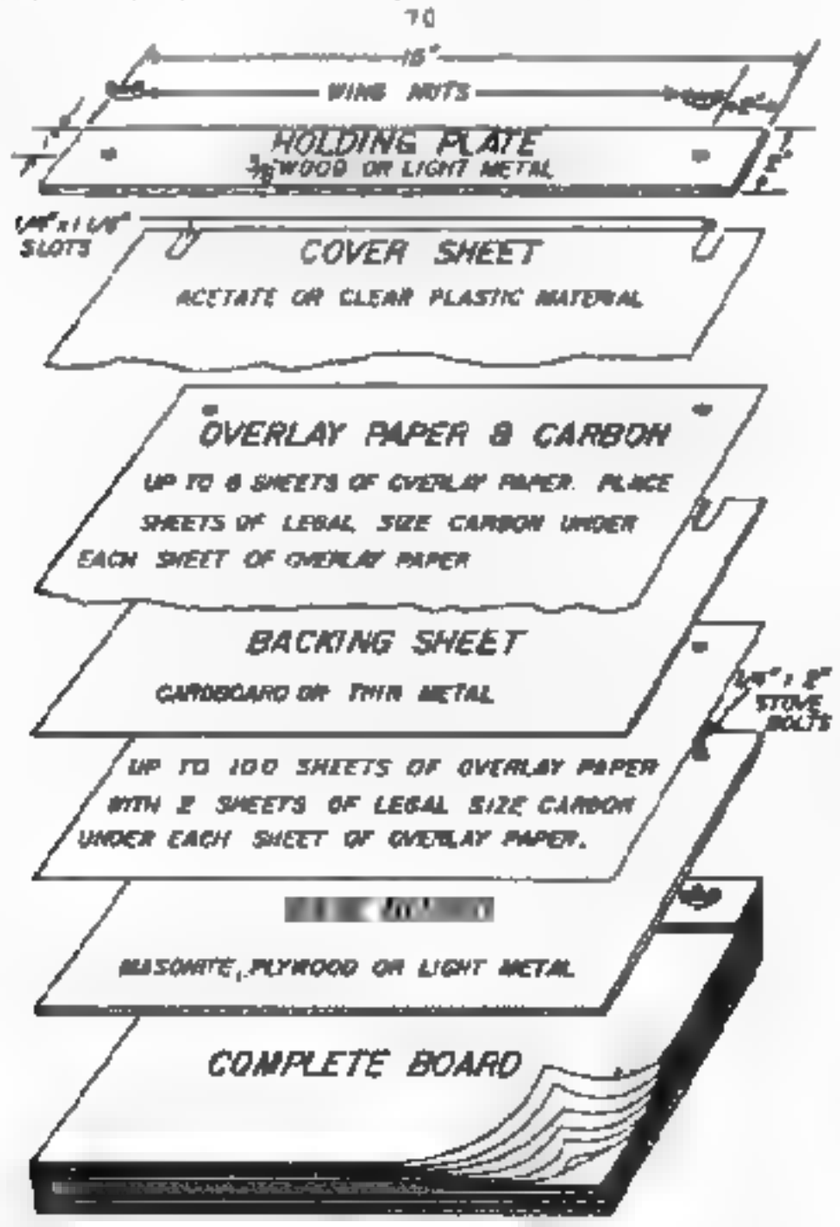

Figure 2

and the backing sheet under the top sheet of overlay paper and formulate the plan. Remove the map and reposition the backing sheet under as many as eight layers of overlay paper. Then retrace your plan from the original overlay sheet using a ball point pen with heavy pressure. The reproduction job is then finished. Remove the holding plate, cover sheet, sheets of overlay and carbon paper above the backing sheet and reassemble for future use.

3. CHECKPOINT CHART (Figure 3) - If you are from the grease pencil-acetate "school" and are working for a commander who delights in controlling movements by use of checkpoints, you are in for trouble if your grease pencil markings become smeared or obliterated. To avoid this, fasten cloudy acetate (rough side up) to your map with small strips of scotch tape, then place your information on the acetate with a soft lead pencil. The acetate may be destroyed by fire if compromise is threatened.

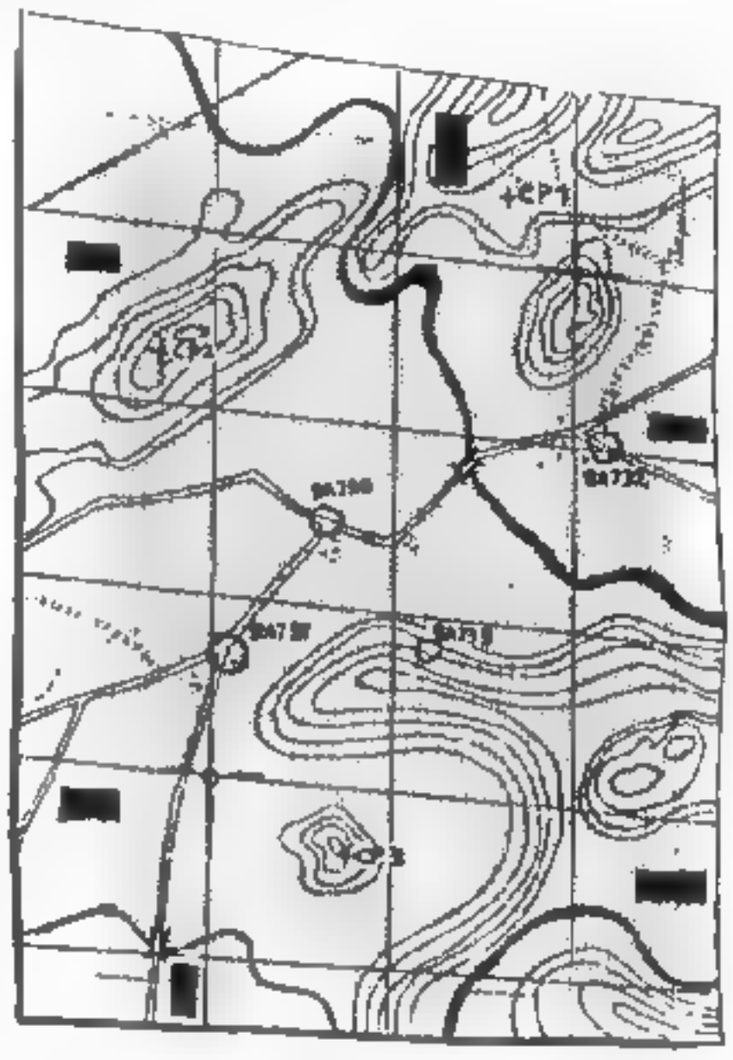

Figure 3

4. "MOUSETRAP" A BRIDGE (Figure 4) - A little ingenuity injected into the classroom improves the atmosphere for learning. A mousetrap, when used as shown here, can simulate the blowing up of a bridge. The aid is most effective when constructed as follows:

a. nail the mousetrap to the surface of a sand table.

b. attach a light piece of string to the bait trigger and run the string to the instructor's side of the table. Test trap and reset.

c. cover the trap and string with sand, taking care not to set off the trap.

d. place the end of the bridge to be blown directly over the mousetrap's "killing bar." Then complete the construction of the sand table.

Similarly, mousetraps can be placed throughout the sand table to simulate artillery, bomb or mortar explosions.

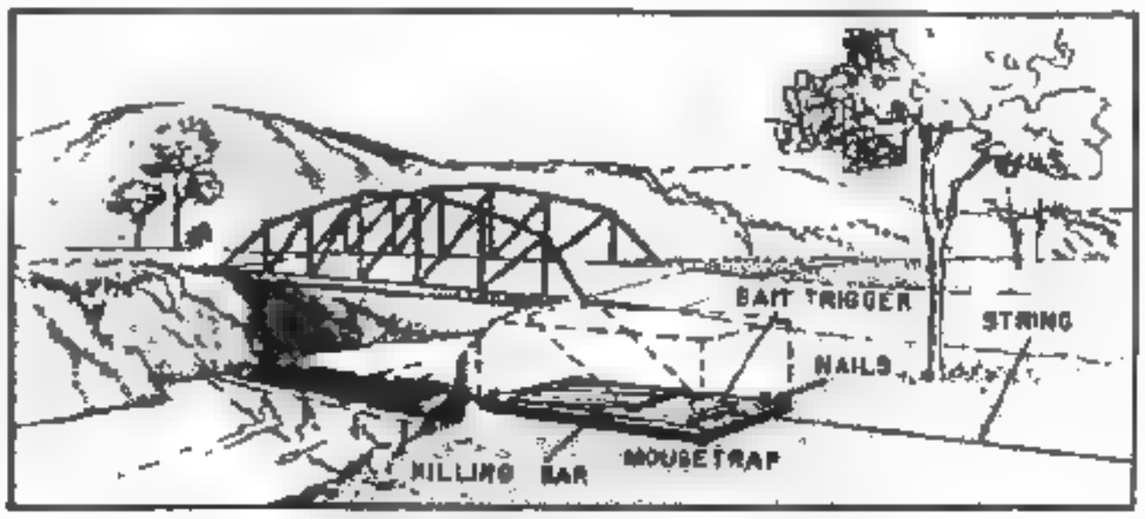

Figure 4

5. MORTAR SIGHT PICTURE (Figure 5) - Teaching new men correct sight pictures for mortar and/or Davy Crockett weapons or just teaching the proper use of the reticle found in military binoculars can be difficult. This training aid makes it easy. It can be produced from a manila folder and a scrap piece of frosted acetate. Once assembled, it is small enough to be carried around for immediate use anywhere. Follow these steps:

a. Trace reticles C, D, and E on a piece of frosted acetate.
b. Cut and fold the base (A) together.
c. Cut out slide B or reproduce on a piece of manila folder.
d. Cut out the jeep and burst on Tab F

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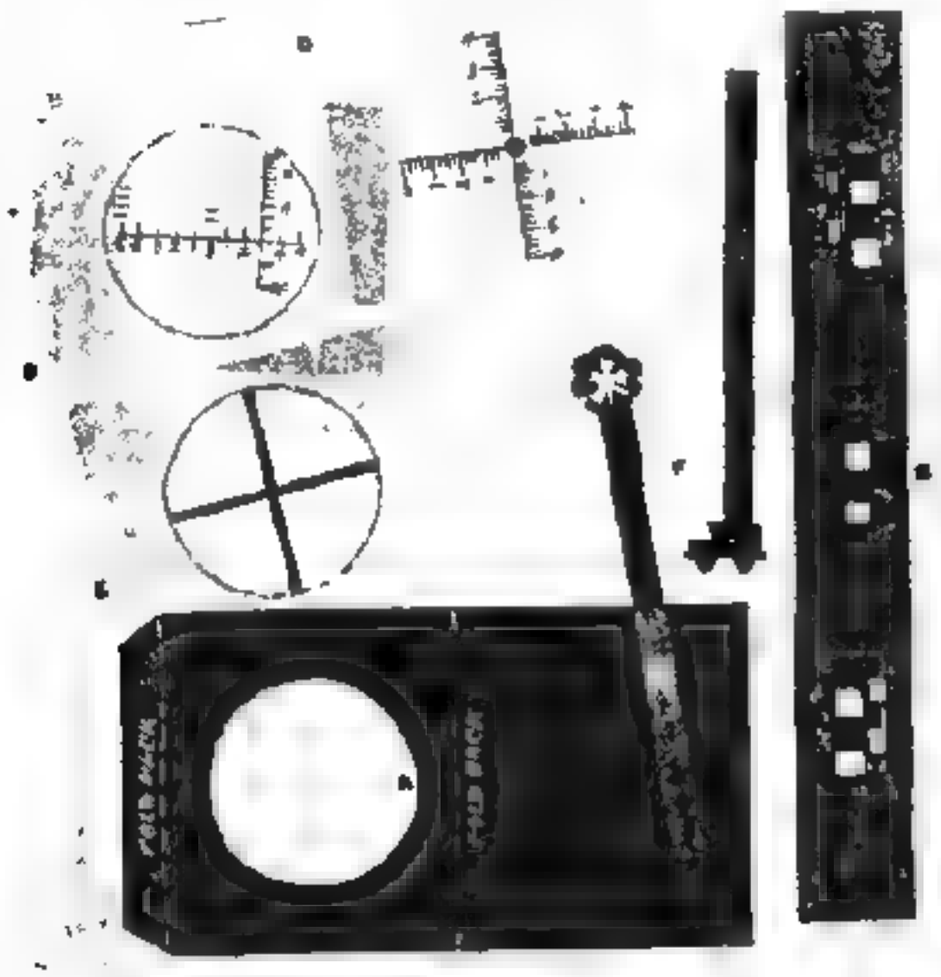

Figure 5

Reticle E inserted in base A and using slide B will enable you to teach sight settings and stake displacement with the mortar

Reticle C inserted in base A and using slide B will enable you to teach sight settings and stake displacement with the Davy Crockett.

Reticle C inserted in base A and using the jeep and burst from Tab F will enable you to teach burst on target method of firing the Davy Crockett.

Reticle D inserted in base A and using jeep and burst from Tab F will enable you to teach the mil reticle found in military binoculars.

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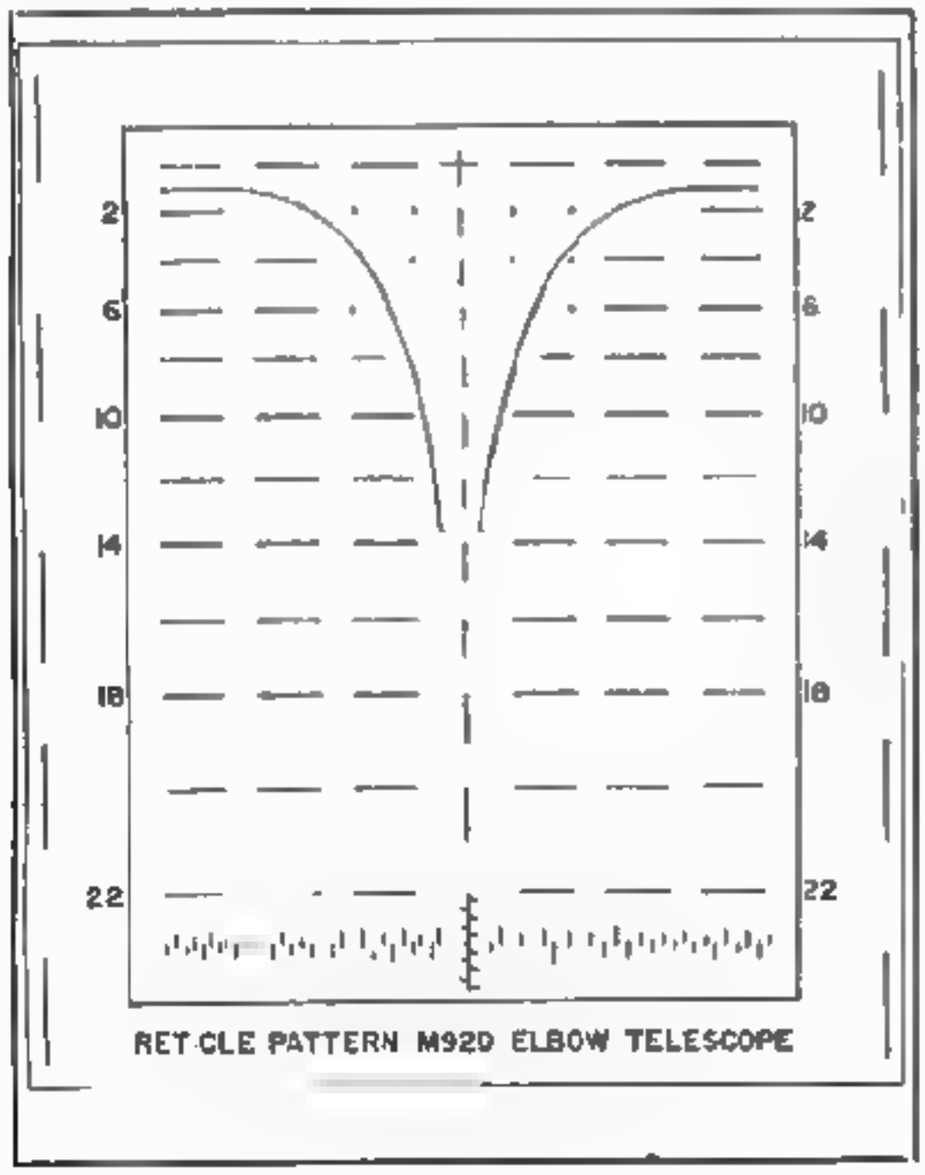

Figure 6

6. M92D TRAINING AID (Figure 6) - Handy for teaching sights and sight

pictures for the 106mm recoilless rifle. The device consists of a holder with markings printed on it, and a movable strip with "targets" printed on it. Steps:

a. Trace the reticle pattern (Figure 6) onto a piece of acetate or strong tracing paper.

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b. Cut from thin cardboard a frame which gives you about a 1/2-inch border all around.

c. To this frame attach the reticle pattern you have traced, gluing the reticle pattern to what will be the underside of the frame.

d. Cut another piece of cardboard to the same outside dimensions as the frame, and then staple together the two pieces you now have. Be sure to staple only along the sides, so that the top and bottom are not closed.

e. Next, cut a strip of light cardboard about an inch wide and 10 inches long (Figure 7). On this strip, sketch three vehicles (a profile, a half-profile and a head-on sketch of a tank).

f. Print, on both sides of the frame enough ranges for the gunner to identify the line he is using or wants to use.

g. Insert the strip into the sleeve and slide in any direction depending upon the target picture wanted.

Figure 7

7. POP-UP TARGETS (Figures 8-10) - handy-dandy for 25-meter expedient firing range.

a. Side Pop-up Target (Figure 8)

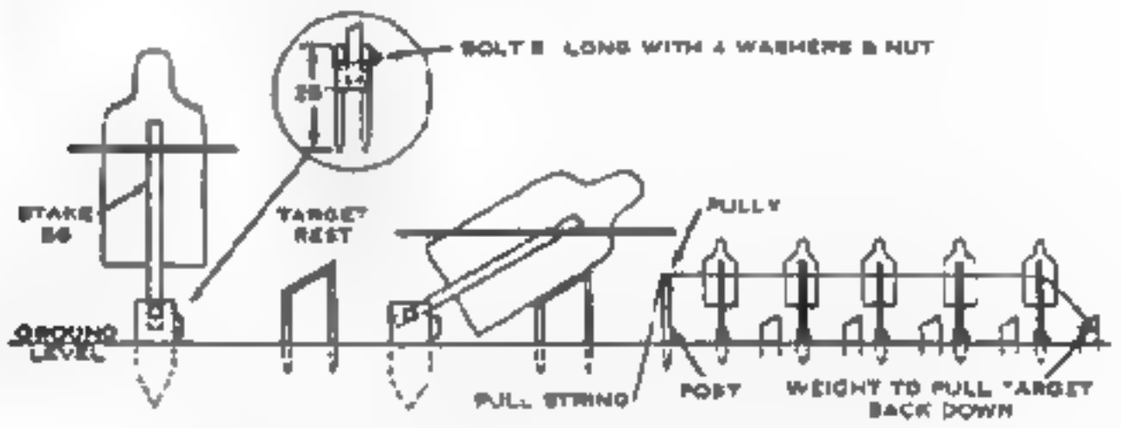

Figure 8

(1) Advantages:
(a) A number of targets can be manipulated by one man.
(b) The targets automatically go down when the pull rope is released.
(c) The operator can be used to score them during the training, thus requiring a minimum of assistant instructors.

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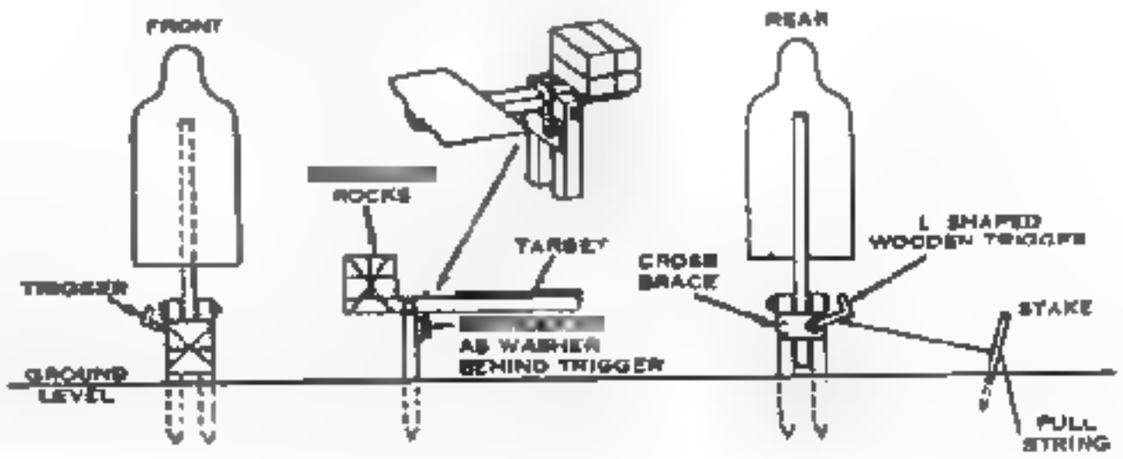
(2) Considerations:
(a) When in the down position, the targets should be just above the horizontal (between 60-70° from upright) so that there is a minimum of strain on the targets and on the rope. A rest can be made of wood but it is just as effective to pile brush under the side of the target.
(b) The target operator should be in a covered position 10 to 15 meters to the flank of the targets. Or a post and pulley can be used so that the targets can be operated from behind the firing line.
(c) When mounting commercial silhouette targets on a stake or board, it is best to use a soda bottle cap as a washer. A nail will often pull through the target and permit it to fall off the stake.

(3) Materials for each target:
(a) 1 silhouette target (commercial or locally made)
(b) 1 wooden stake, 56" long
(c) 2 wooden stakes, 25" long
(d) 1 bolt, 5" long (metal rod from ammunition box will work here)
(e) 4 washers (bottle caps will do the job) and a nut for the bolt
(f) 1 piece of wood to use as a crossbrace, 4" long
(g) 1 target rest (wood, brush, etc.)
(h) pull rope
(i) nails and bottle caps
(j) camouflage materials



b. Counter-balance Pop-up Target (Figure 9)

1) Advantages:

(a) This type is most effective where the terrain does not permit employment of straight lines of targets

(b) As each target is activated singly, the student becomes conditioned to the fact that he will not see all the enemy at the same time and

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that he must recheck any area which he initially scanned and found to be empty of targets. Also, this type target provides the realistic factor of distracting movement in the vicinity of another target which a student may be engaging.

(c) It is particularly good in a small jungle lane or in other restricted areas.

(d) This type of target can be set up so that the firer himself activates it by stumbling over a trip wire

(2) Considerations.

(a) This model target must be reset after use, it will not go down automatically.

(b) Activation of this target is by means of an "L" shaped trigger located at the rear of the target. Pulling on the rope draws the trigger away from the target and the weights on the far end of the stake swing the target into an upright position.

(3) Materials

(a) 1 silhouette target

(b) 1 stake, 56" long

(c) 2 stakes, 25" long

(d) Weight for counterbalance (bricks, rocks, an ammo can filled with dirt, etc.) that can be fixed onto the stake.

(e) "L" shaped piece of wood and a bottle cap which it will pivot on.

(f) 1 wooden cross brace 4" long

(g) 1 bolt w/nut and four washers (bottle caps, etc.)

(h) suspension line, rope, string, etc.

c. Front Pull Pop-up Target (Figure 10)

(1) Advantages.

(a) Target is simple to make and operate.

(b) Target will go down automatically when the pull rope is released.

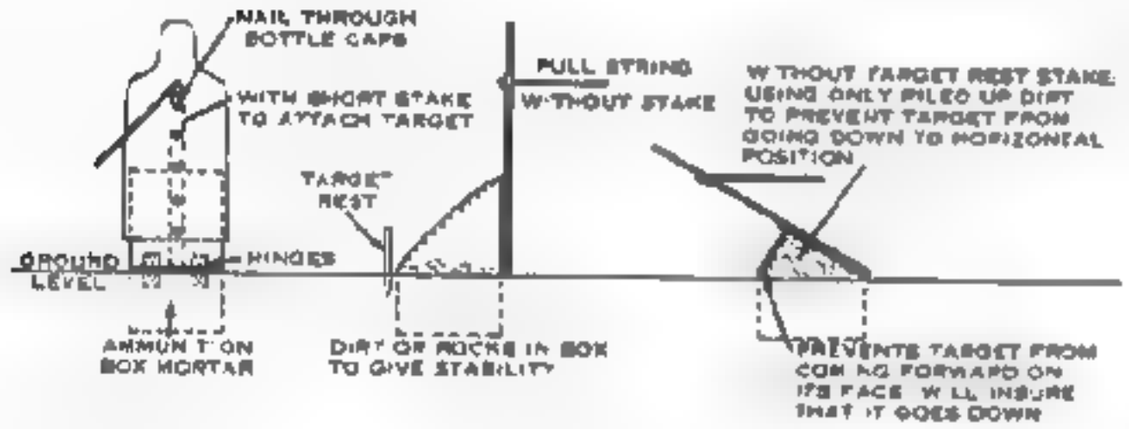

Figure 10

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2) Considerations:

(a) When down, the target should be above the horizontal. This can be accomplished by piling dirt in the box or by placing a stake behind the target

(b) In construction, the target is simply nailed to the lid of a hinged ammunition box (mortar, grenade, etc.), and a rope is used to raise the lid of the box.

(c) The box should be buried in the ground and the soil placed into the box to provide stability.

(d) A short length of wire or string from the lid of the box to the rear edge allows the lid to come up to slightly less than a perpendicular position, thus ensuring that it will drop when the forward pull is released, and preventing the target from being pulled forward onto its face.

(e) These targets are operated from the firing line by the coach who is working with each firer.

(f) These targets are best used during the early stages of training when the students are not moving.

Example: on a transition course where unarmed fire and the use of available cover are being taught.

(4) Materials

(a) 1 silhouette target

(b) 1 ammunition box

(c) Suspension line or rope

(d) Nails, bottle caps, etc.

8 EXPEDIENT TRANSPARENCIES FOR VU-GRAPHS

Type A

a. Limiting Factors

(1) Original picture is destroyed

(2) Size of pictures sets size of transparency

(3) Picture must be printed on clay-coated paper (Time, Life, Look, Aviation Week)

b. Steps (takes 15 to 50 minutes)

(1) Choose the picture. If black and white, ink coverage should be good and quality of photo should be high. Color photos work better but must be in good register

(2) Test for use. To determine if the paper is clay-coated, rub a moist finger over an unprinted area. If white chalk residue shows on the finger, the paper is OK to use. This clay coating will release the ink and permit a transfer of the image

(3) Coat the face side of the picture with rubber cement after removing from the magazine. Leave a margin. Coat with a smooth, even, thin layer of cement using a soft brush with fast even strokes. Allow to dry for 15 minutes.

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(4) Coat the frosted side of acetate with rubber cement. Allow to dry.

(5) Adhere the rubber cement surfaces of the two. Be careful. If bubbles form, pierce them with a sharp needle from the paper side. Take a smooth, hard object and rub over the back of the picture to ensure good adhesion.

(6) Soak in cold water. Add some detergent to help the water soak through the paper surface. Leave "sandwich" in water 5 to 10 minutes.

(7) Remove the paper from the acetate gently. Soak some more if the paper won't release easily from the acetate surface.

(8) Wash off the clay. A light film of white chalky material will appear on the picture-acetate surface. Wash this off with a piece of soft cot-

(9) Clean the transparency. Get off dirt, etc.

(10) Dry the transparency. Blot off excess water and allow to dry for at least 10 minutes. Spray the rubber cement surface with a good grade of crystal clear plastic spray.

(11) Bind the transparency or use as is.

Type B (Figure 11)

a. How it works - this type transparency consists of a translucent master on which an image is drawn, printed or photographed, and a sheet of diazo-coated film. To make a transparency, you just expose the master, in good contact with the coated or sensitive side of the film, to an ultra-violet light source (sunlight). The ultra-violet light penetrates the master and "burns out" the diazo coating of the film where it is not covered by a drawn image on the master. The exposed film is then subjected to aqua-ammonia vapor which develops on the film an exact replica of the image of your master.

b. Materials

(1) A sheet of translucent material (overlay or tracing paper) size 8 1/2 x 11".

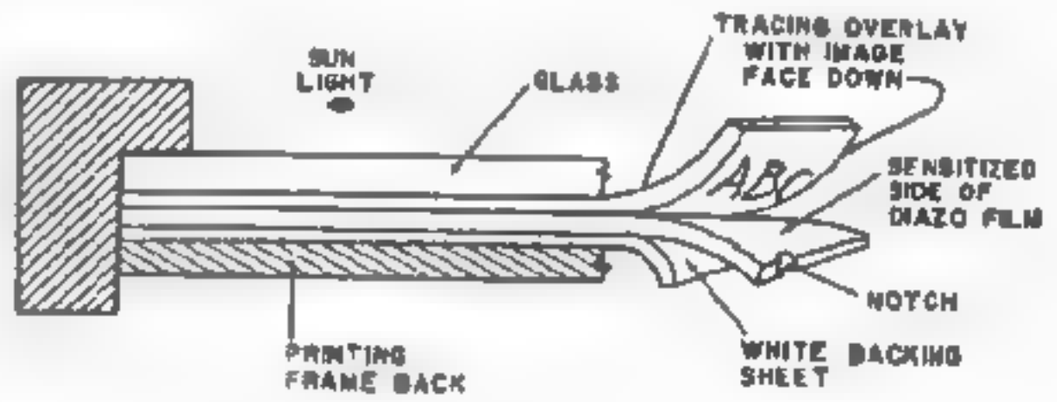

Figure 11

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(2) Black drawing ink and drawing pen, or soft drawing pencils (HB, H, 2H). (Ink reproduces better.)

(3) Diazo film, size 8 1/2" x 11"

(4) An inexpensive 11" x 14" photographic printing frame, or 2 sheets of plate glass hinged on one edge with tape (slightly larger than 8 1/2" x 11")

(5) A wide-mouthed glass jar (pickle jar) with a sponge in the bottom

(6) A few ounces of commercially available aqua-ammonia 26° Baume).

c. Steps

(1) Take a sheet of ordinary bond paper (8 1/2" x 11") and draw 1/4" squares in dark pencil. Mark off an 8" x 10" area in the center. Place three registration marks outside the 8" x 10" image area. This is a grid sheet and is used for registration, spacing, centering, etc.

(2) Tape this grid sheet to your drawing surface and tape corners of a piece of 8 1/2" x 11" overlay paper over it. Trace the registration marks onto the overlay (master sheet). The registration marks are for additional "drop-ons" that you may want to make for your basic transparency.

(3) Do your drawing or lettering within the 6" x 10" area that you should be able to see from your grid sheet.

(4) (a) Diazo films come in different sensitized color coatings, each color packaged separately. All color coatings appear clear or pale yellow when coming from the package and all look the same. The color does not appear until development.

(b) Pull a sheet of diazo film from whatever color package you have decided to use. You will notice a small notch in one corner. When this notch is in the upper right-hand corner, the sensitized side is facing you.

(5) Placing the notch in the upper right corner lay the diazo film on a white backing sheet that comes between each sheet of film. Cut the two into strips about 1" wide. These strips are to be used in testing exposure time.

(6) Lay your drawing overlay on the sensitized side of the film,

drawing side down and in contact with sensitized side of film.

7) Place in printing frame in this order: overlay next to glass, strip film next, backing sheet next to back.

(8) Clamp the back on the printing frame. The overlay (master) should be next to the glass so that sunlight can penetrate the tracing paper and then the film in that order.

(9) Expose one test strip at a time, at 30-second intervals, in sunlight (approximately 1 minute to 4 minutes) to determine correct exposure.

(10) Your pickle jar developer should have a sponge and about 2 tablespoonfuls of aqua ammonia in the bottom of it. Place exposed test strips, one at a time, into the jar and screw on the cap quickly. In about 3-5 minutes you should have a fully developed image on the film. If exposure time is correct, the background should be clear and the image dark, depending on color

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film used. You cannot overdevelop, consequently, exposure time is the most critical. If you overexpose the image will be faint and the background clear after development. If you underexpose, the image will be very dark, and the background will be dark after development.

(11) When correct exposure time is determined, try a whole sheet of film with your master and repeat the above exposure and development steps.

(12) After development remove from the pickle jar and mount. You can then project.

NOTES

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IX. Miscellaneous

1. CANNED HEAT - When troops must operate in cold or wet for long periods, canned heat can be valuable in preventing cold weather casualties. If the clothing or boots have become soaked and no heated shelter is available for drying them, they may be dried in the following manner: the individual puts on his poncho and sits on the ground or in a hole, making the space under the poncho as airtight as possible. By burning canned heat in this space, the air under the poncho is made so hot and dry that drying of wet clothing and footgear takes place rapidly. A reasonable amount of care must be exercised to prevent burns on the poncho or other equipment, and to get maximum benefit from the heat generated.

2. ASSEMBLY/PARKING AID - To mark assembly or parking positions during blackout movement, use empty metal 7.62 ammo boxes with holes punched in one side to indicate the unit or vehicle. The quartering party or advance party places flashlights in each box and faces each perforated side toward the approach of the main body. When the main body arrives, units pull in by the appropriate marker box.

3. FISHING AID - Connect two 8-foot pieces of commo wire to binding post and strip the last two feet of insulation from each end. Weight the ends down with any metal object (clips, magazines etc.) and drop into stream. Turn the generator handle vigorously, and fish will come to the top. Not recommended for peacetime use in areas patrolled by strict game rangers.

4. WIRE FOR CONTROL. During an ambush or night attack, take a piece of wire (commo wire will do) and attach it to the support element leader and patrol leader. When the patrol leader is ready to open fire, all he has to do is jerk the wire to signal for the machineguns in the support element to commence firing.

5. EXPEDIENT MAP CASE - Take a piece of clear plastic automobile seatcover material 26" long and 12" wide; fold a 6-inch section from each end toward the center; stitch along the upper and lower edges of the folds, thus forming two 6"x12" pockets in which a map may be inserted. Useful features.

a. unobstructed viewing area 12"x14" on front and rear when it is open.

b. water resistant.

c. completely flexible--may be rolled or folded.

6. PORTABLE BARRIER - made so it will fit into a 1/4-ton trailer when collapsed. Need eight 6-foot lengths of 2x6 lumber joined together with bolts (Figure 1). Forms a 12-foot span when erected. When not in use, the barrier may be collapsed by removing the bolts holding the upper horizontal brace

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and one bolt from each lower horizontal brace. This will permit each cross-brace to be folded for storage or transport. Replace loose bolts in holes to avoid loss. Use with wire, Claymores or other obstacles.

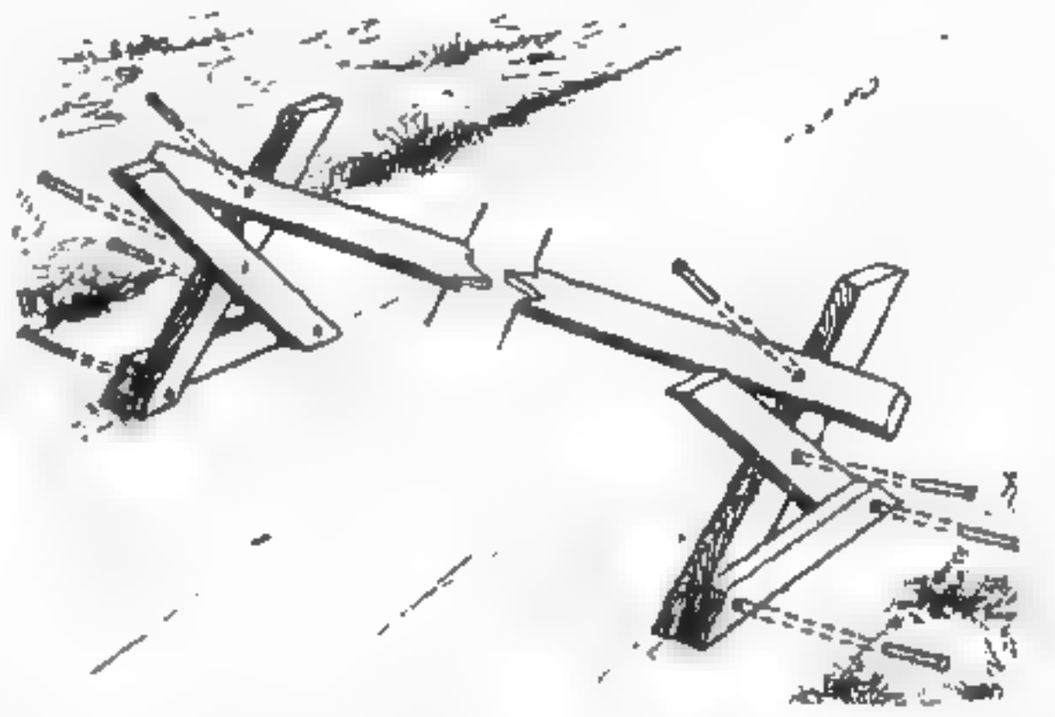

Figure 1

7. WATERPROOF MAP - lay map sheets to be treated on a flat surface and apply an even coat of lacquer by spraying or brushing. Normally, two coats will be sufficient for average use. Let each coat dry for at least 10 minutes. After treatment, the maps may be rolled, folded or wrinkled, but will still maintain their shape and appearance. Grease pencils may be used for marking on the map and easily erased.

8. MAP FOLDING (Figures 2 - 4) - for a starter, get a map or a piece of practice paper, some glue or transparent tape and a razor blade. Now we're ready to start:

a. Lay the map face up on the table.

b. Fold it in half. (Turn the bottom edge up to meet the top.)

c. Crease the folded map into three equal parts with the creases parallel to the center fold

d. Open the map completely and lay it, face up, in the normal position. Turn it so that east is at the top and fold it in half as in Step b (fold the

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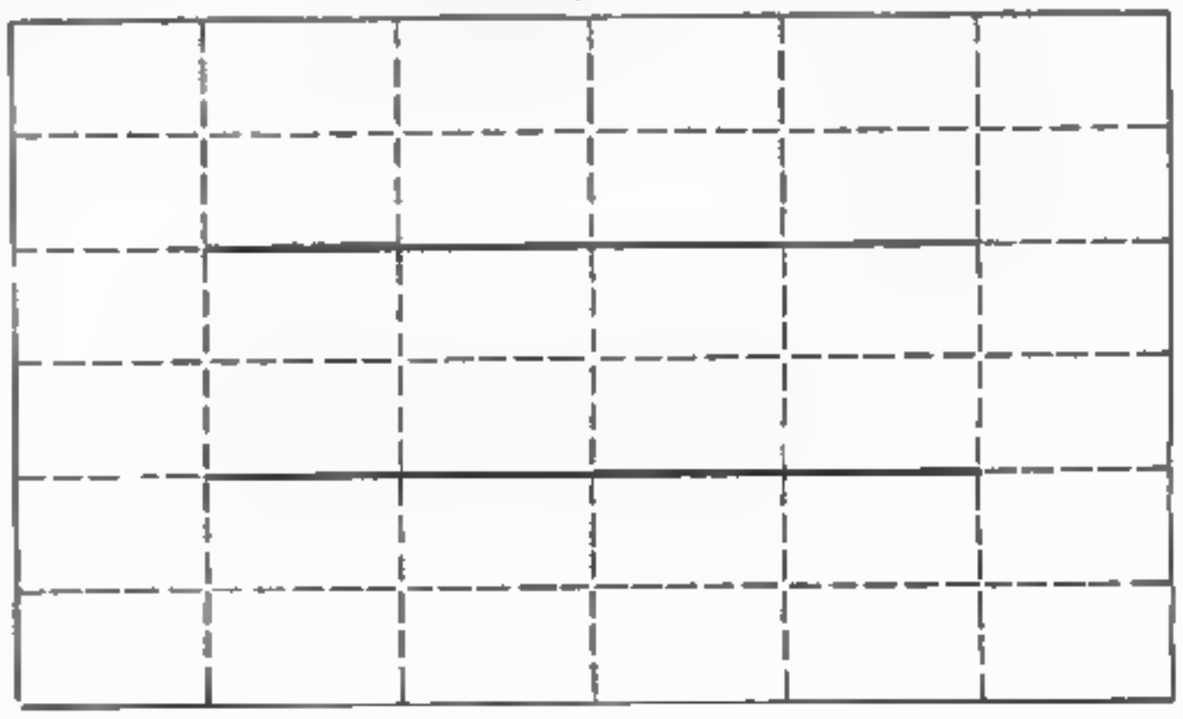

Figure 2

bottom to the top). Again crease the folded map into three equal parts with the creases parallel to the center fold.

e. Open the map completely and lay it face up (with north in the nor-

mal position at the top). It is now creased into 36 equal parts. Using the razor blade, cut as indicated by the heavy lines.

f. Next, position both hands in such a way that the fingers and thumb of each hand straddle the second crease from the top. Draw the paper up so it will fold at this crease and then fold over toward the top edge. Draw the paper up at the second crease from the bottom to meet the top edge. An "edge view" of the map should now look like three V's together.

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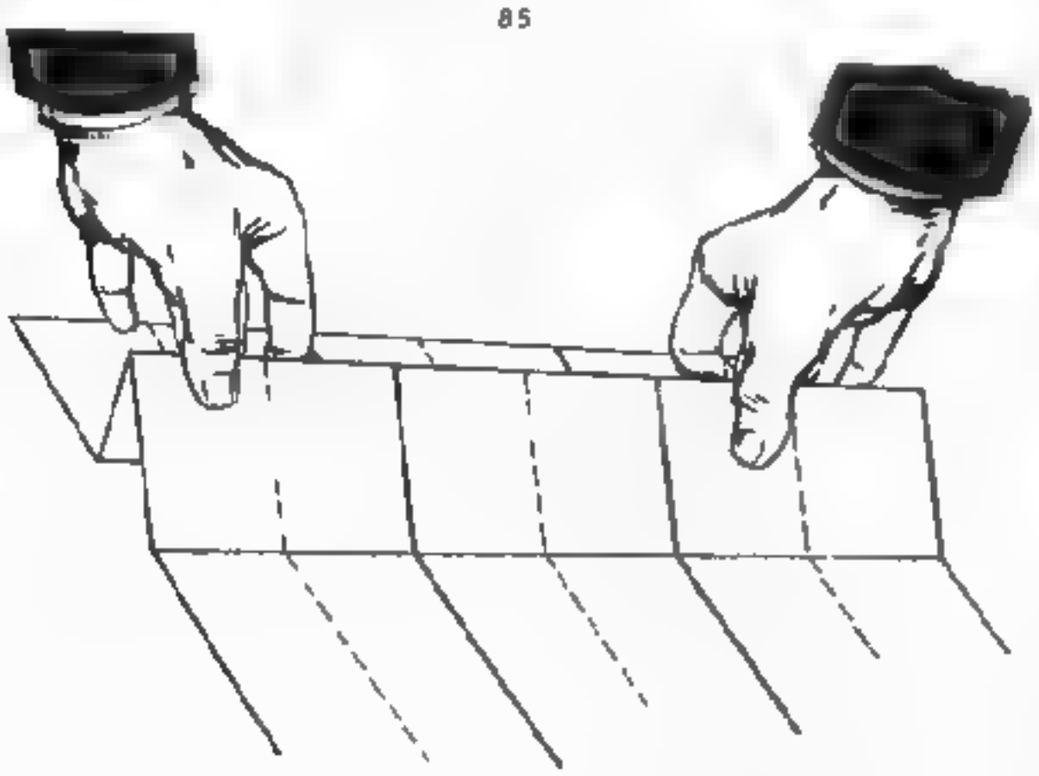

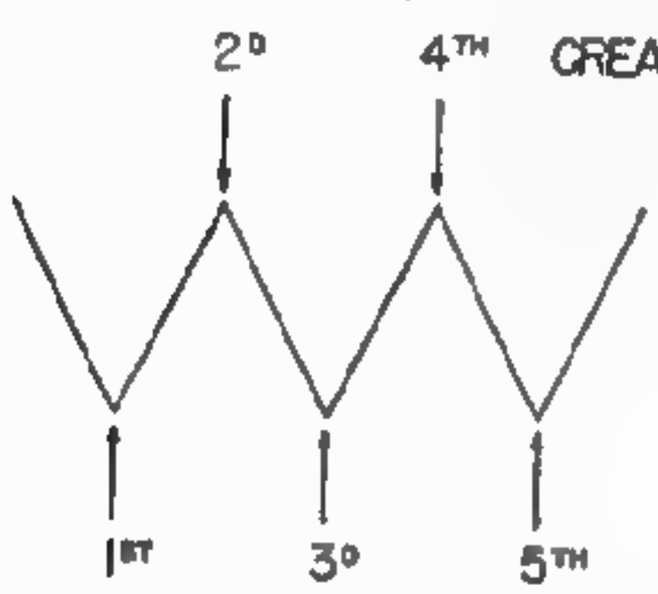

Figure 4

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g. Open the map to the center section (without unfolding the remaining) and turn it so that east is at the top. Straddle the second crease from the top as in Step f. Draw the paper up and fold toward the top as before. Repeat the procedure with the second crease from the bottom, and fold the bottom edge up to meet the top, all as in the previous step. An "edge view" will again look like three V's together.

h. Allow the map to open at the middle V and to lie flat on the table, exposing the center section without unfolding any other parts. Apply glue to the adjacent backs of the map where the cuts have been made or bind the cut edges together with transparent tape. The sectors, so joined, may be turned as one page.

The map is now ready for use. It is 1/9 of the original size and need not be unfolded to find any feature of sector. Any point can be located by turning the flaps up and down, left and right. The map may be indexed for quicker reference by labeling the three sections of each lateral strip: "A^1," "A^2" and "A^3" (top), "B^1," "B^2" and "B^3" (center) and "C^1," "C^2" and "C^3" (bottom).

If you turn the center section up or down when reading the map, you must turn the corresponding flaps on the left and right sections in the same way to remain on the same strip. For example: strip "A" is revealed when all the flaps are turned from the top toward the bottom. When you have finished with the map, return the flaps to their original position so the whole map will lie flat.

The map may be glued into a manila folder for protection and easier use, however, it will have to be opened to 2/9 size in order to find all features and sections. Simply apply glue to the four bottom back corners and align the center crease of the map with that of the folder. If you wish to carry the map in a pocketsize notebook, fold it to 1/36 size and glue it to the notebook on one of the back corners. The map may be opened to 1/9 size for reading.

Before you actually cut your map, practice this technique on plain paper, using a straight-edged guide for the blade. This method of map folding works with all maps including those composed of sector-sheets which have been glued together.

9. EXPEDIENT PEN -

MATERIALS:

a. One salvaged retaining clip from a salvaged helmet liner band.

b. One 10 or 12 penny nail (can be an old one) or similar piece of wood or pen staff.

c. One piece of wire (or cord) 12 inches long.

d. A cutting file or hack saw blade.

CONSTRUCTION (Figures 5 and 6):

a. Remove salvaged retaining clip from salvaged band (see Figure 5).

b. Press open ends of the clip together until they are fastened securely.

c. Press or hammer flat surface of the clip (not the two rounded ends) until it is not less than 1/16 inch thick nor more than 1/8 inch thick.

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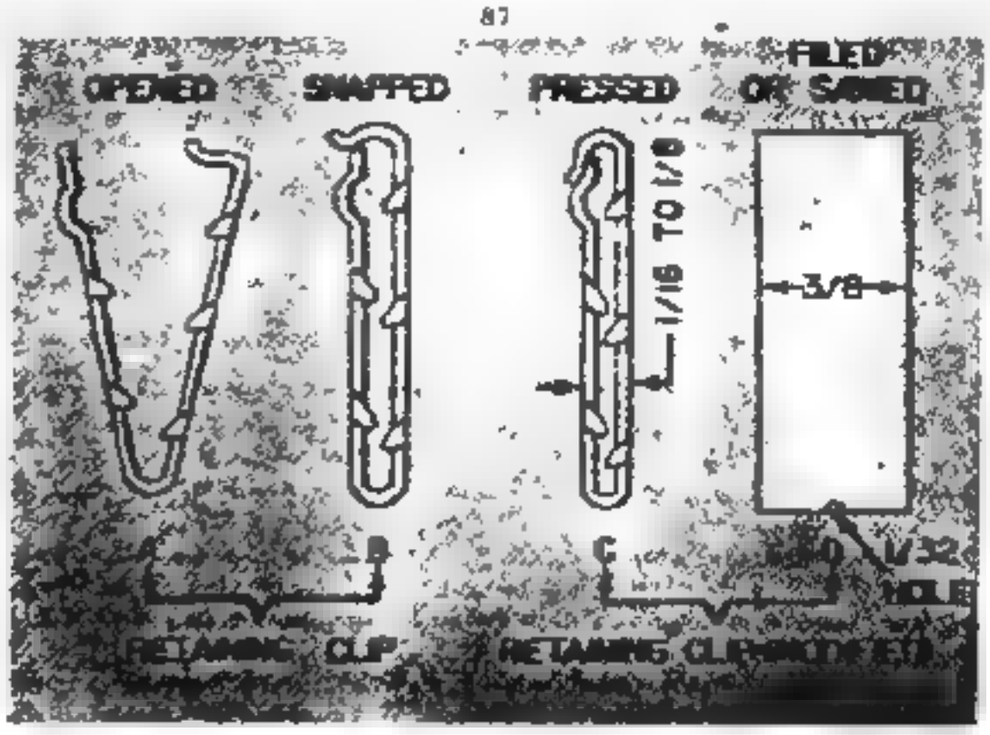

Figure 5

d. Saw or file a narrow notch not more than 1/32 inch wide in the exact center of the rounded end of the clip. This notch must be deep enough to go through the thickness of the metal.

e. Fasten the modified clip securely to a 10 or 12 penny nail or a piece of metal of similar size (see Figure 6).

USE:

a. Dip into ink until the tip of pen is 1/2 to 3/4 inch covered.

b. Place on writing surface--pause a moment--then proceed.

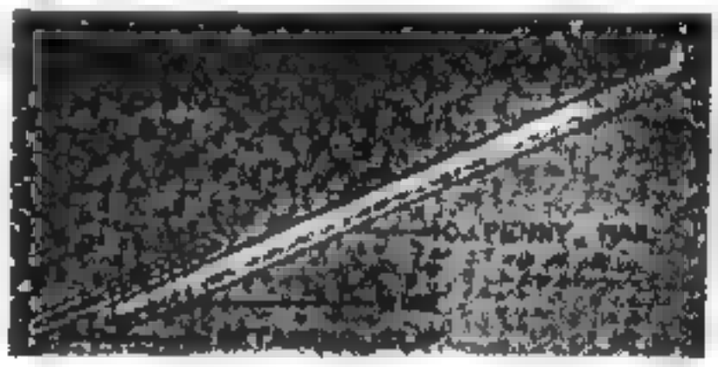

Figure 6

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c. Firmly (but not stiffly), draw the pen toward you.

d. For drawing thick and thin lines, hold the pen at a 45° angle.

If you want narrow lettering pens, follow the construction procedure indicated above but file each side of the pen point until it reaches the desired width. If a wider writing surface is desired, place two of the modified clips side by side. Secure them on an appropriate staff. Be sure to place a nail or piece of metal through them to keep them in line.

10. EXPEDIENT PRINTING -

a. BANANA LEAF SPECIAL - Any broad leaf which is still green (so that it cuts easily) will work. It is important that only broad lines and a bold design be used. Copy the design in pencil on the underside of the leaf. Using a razor blade or sharp knife, cut out the letters and design leaving enough "bridges of leaf" through the design to hold the stencil together. Place the completed leaf stencil, underside up, against the surface on which you want to print. A leaf stencil may be used to print on trees, buildings, cloth or paper. Using a brush, rag and almost any kind of ink or paint thick enough not to run, ink the open areas of the cut leaf and remove it.

b. RAW POTATO PRESS - A large, hard potato is the tool required here, although beets or even carrots may be used. The design must be simple and limited in size. A symbol (such as the Circle Trigon if you are playing Aggressor) is a good design for a "raw potato press." Cut the potato in half (lengthwise) so that the cut surface is flat. With a pencil, draw the design in reverse (mirror image) on the cut surface of the potato. Cut down that portion of the potato which is not to print so that the design is a plateau about 1/4-inch above the rest of the potato surface. Let the potato dry for several hours so the ink will not smear when it is applied. Ink the "raw potato press" with an ink pad or inky rag. Press the inked potato against paper or other flat surface. If the surface of the potato was not cut flat, a better image may result if you put some padding under the paper to receive the image (several layers of newspaper will do).

MODERN GUNSMITHING

A Manual of Firearms Design, Construction and Remodeling, for Amateurs and Professionals

by

CLYDE BAKER

SECOND EDITION, 1933

SMALL-ARMS TECHNICAL PUBLISHING COMPANY

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THE AMERICAN RIFLEMAN

JUNE, NINETEEN FORTY-THREE

Clyde Baker

One of the most popular contributors to RIFLEMAN pages, Clyde Baker, author of many home gunsmithing articles, died April 8, 1943. In ill health for some time he entered Oak Noll Naval Hospital on March 22 and passed away following an operation.

Mr. Baker was born at Cowgill, Missouri, March 26, 1894, but received most of his schooling at Kansas City, Missouri, where his family moved.

At the outbreak of World War I he enlisted in the Marine Corps and had nine months service in France. Upon returning to the United States and his home he went in for the hobby he always loved—guns, gunsmithing and repairing.

In 1922 he married Edna N. Mengel and then, in his own home, established a gun repair shop where he remodeled, rebuilt, repaired and restocked guns of all types in his spare time. His occupation was advertising. It was during this time he wrote his book, "Modern Gunsmithing," which became one of the most enthusiastically received writings of that subject. He was a lover of the outdoors and hunting came to him naturally. That and his gunsmithing hobby provided the material for the many articles he wrote for THE AMERICAN RIFLEMAN, *Sports Afield, Mechanix Illustrated, Outdoor Life* and others.

After Pearl Harbor Mr. Baker answered the Navy's call for men with specialized trades. Then being in the gun business entirely, he enlisted and soon was assigned to

instruction on the subject of "Guns and Gunnery" at San Diego. In July, 1942, he was assigned to special duty at the U. S. Naval Base at Oakland, Calif., where he worked in a small arms repair unit. Everywhere his fine work and gunsmithing ability was recognized and he was made Gunners Mate 1st Class last February.

Clyde Baker will live long in the memories of those who loved the outdoors, fine firearms and expert worksmanship.

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INTRODUCTION

SOMETHING over a year ago, in writing to Dr. Paul B. Jenkins, then shooting editor of Outdoor Recreation, I made the statement that there were a number of points I should like to have seen discussed in Whelen's "Amateur Gunsmithing" which were not covered therein. Apparently Dr. Jenkins was impressed with the outline of features which I thought would be of value to the gun crank as well as the professional gunsmith, for he sent my letter to Colonel Whelen without more ado.

Now the Colonel, being the most agreeable of men, frankly stated that "Amateur Gunsmithing" was not as complete as he should like to have made it, being the first work on the subject, and requiring original investigation, for which time was limited. And in further evidence of his devotion to a good cause, he cordially invited me to write the kind of gunsmithing book I was talking about, generously offering me any or all of the original material in his book, and his personal cooperation in the new enterprise as well.

If at first I felt flattered by the invitation, the feeling was quickly dispelled by the realization of what a big mouthful I had bitten off for myself; I was pretty much in the same situation of the nigger who caught a wild-cat by the tail—"couldn't hang on, an' dassent let loose!" But as all things must eventually have an ending, the last line was finally written, the last photograph made; and from the heart of the continent there sounded one long drawn sigh of relief.

It is evident that a book of this character cannot in the nature of things be entirely the work of one man. In the field of gunsmithing, as elsewhere, we unconsciously lean toward specialization, doing more of the work we like best, and less of the work we do not understand so well, or for which we are not so well equipped. In "Modern Gunsmithing," therefore, my work has been quite as much that of a compiler as of an author; the meager results of personal experience have been enlarged by adding the experience and knowledge of others, with a view to placing in the hands of gunsmiths and gunowners the greatest amount of useful material and information, regardless of its source.

There seemed to be a definite desire on the part of a large number of shooters for a textbook of gunsmithing practice, and every effort has been made to incorporate in "Modern Gunsmithing" detailed instructions covering those jobs most often required by the gun-crank.

There are some who will scoff at this suggestion, pointing out that the high degree of skill acquired by expert gunsmiths was not acquired by reading a book, but through long apprenticeship to the trade; and pointing out also the elaborate and costly machinery necessitated in the manufacture of modern firearms. All this is true; and it would be not only futile, but silly, to claim that this or any other text book would place the amateur workman or the gun-crank on a par with the expert of long experience, or enable him to perform all the intricate mechanical operations possible only in the well equipped factory shops.

It has been our purpose, therefore, to cover as thoroughly as possible those jobs which can be considered practicable for the amateur workman, and for the gunsmith with a small shop and limited equipment, and to show not only the possibilities, but also the limitations of amateur gunsmithing. And while some of the jobs described may prove to be beyond the ability of some workmen, they will, it is hoped, serve a useful purpose in bringing to the gunowner a greater appreciation of the guns he owns—of the skill and material which enter into their makeup—at the same time showing the fallacy, perhaps, of some of the things which shooters demand of the factories—things which are clearly impossible or impracticable once the subject is better understood.

It is hoped also, that our work may serve another useful purpose, in the way of a warning against a type of gunmaker who sneers at the work of our great arms factories and offers, in some mysterious manner which he carefully conceals from the trusting customer, to do things which the factories, with all their experience and costly equipment, do not claim to do.

We are tempted at times, of course, to take exception to the attitude of our large factories, when they refuse to give us something which we think we want—which refusal is always necessitated by the fact that the factories are lined up for regular production, and cannot, in the nature of things, go into custom work without involving more expense than the job would bring. But before we start cussing them let us remember that the products of our old established factories, while they may not always suit us in certain minor details, are pretty certain to be dependable, accurate, and to live up to the very modest claims of the makers. Which is a blamed sight more than the products of some custom shops will do, despite the gold dogs, the flubdubs, an the furbelows with which they are embellished.

A large portion of the credit for "Modern Gunsmithing" belongs to Lt. Colonel Townsend Whelen, without whose untiring energy and splendid cooperation the work would not have been possible, and would not have been attempted. In fact, though he modestly refuses to have his name attached as co-author, he wrote the chapters on barrel work and cartridge design and construction. I wanted these chapters to be absolutely authoritative, and I know of no man so well qualified as he is to cover the subjects.

I wish to acknowledge also the very valuable assistance rendered by Major Julian S. Hatcher, Mr. James V. Howe, Mr. Frank J. Kahrs, Mr Lou Smith, Captain Edward C. Crossman, the Lyman Gunsight Corporation, the Marble Arms & Equipment Company, Remington Arms Company, Hunter Arms Company, Parker Gun Company, Fox Gun Company, Ithaca Gun Company, and other firms and individuals who have been so generous in the matter of supplying needed data or illustrations; and I am most grateful also to the several individual shooters, some of whom I have never met, who have come to the front with interesting illustrations of their own handiwork, besides their many valuable suggestions.

Last but not least I am indebted to the publishers for the many constructive criticisms, chapter by chapter, which have prevented the possible omission of much important data that might easily have been overlooked, and whose assistance in the matter of securing the cooperation and aid of leading firearms manufacturers, has proven invaluable.

The preparation of this book has taught me that the best way to really learn something about a given subject is to attempt to write a book on it!—and if the reader acquires half as much new information from reading "Modern Gunsmithing" as the author acquired in the writing of it, he will find, I hope, that his effort has not been entirely wasted.

Kansas City, Mo. CLYDE BAKER.
July, 1928

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CHAPTER 1

HOME GUNSMITHING

"HELLO, Bill!"

"Howdy, Frank! C'min."

'Believe the weather's cool.n' off a bit, ain't it?—for heck sake, whatcha doin' there—makin' a gun?"

And Bill smiles. "Well, not exactly. Just a new stock for one of my old ones."

"One of 'em! How many you got, anyhow?"

'Oh, not many, I guess. Four rifles, my old Parker 12 that I use for ducks and a 20 gauge Smith for birds, and four or five pistols—not counting a coupla target pistols I made out of .22 rifles."

'My Gawd! You figurin' on startin' a revolution or something."

"Nope. Just like to shoot, and fool with guns. What did I do with that other file?"—and Bill rummages among the odds and ends on the bench. Frank watches him a moment.

"Say, ain't that some kind of an old army rifle?—that thing sticking out on the side looks like the ones we had at Funston during the war. Boy, I sure was glad to get rid of mine!"

"Well, this isn't an old army rifle, exactly, though it is a Springfield barrel and action. This is the 'Sporter' model sold by the Director of Civilian Marksmanship to members of the National Rifle Association."

Frank inspects the gun with a knowing air. "Um-m huh! Thirty-thirty, ain't it! Boy!—how far will that thing shoot?"

"Can't say. Depends on how high you hold it. I'll sight it in for a hundred yards for hunting."

"Aw hell—I bet that thing 'ud carry clear over into the next county! Wha'd'ya want with a thing like that around here for anyhow—can't use it in this country can you?"

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By this time Bill is becoming somewhat nettled. "You can if you're not crippled! I get out for a little shooting on the range most every Saturday and Sunday. Don't have much time through the week. Now and then I get down along the river and throw a few at the driftwood, and such, as it floats down. Great sport, that—good practice for game-shooting, too."

"Game shooting—shucks—there ain't no game 'round here."

"No, not right out here in the yard. But I don't have to go far to find rabbits and squirrels, and usually get my share of birds and ducks in season. And last fall I got a prime elk and a nice bear out in Wyoming—and this fall I'm going up in Idaho with a friend of mine whose brother owns a ranch there. There's plenty of shooting if you know where to find it—and besides there's no closed season on targets, tin cans, chunks of driftwood. Yeah, I reckon I'll get my share of shooting, as long as they make powder!"

Frank gapes, open mouthed. "My gosh! I didn't know you was such a hunter. Lemme see one o' them bullets. Wow! That thing'd tear right through an elephant an' keep on goin', wouldn't it? Looka' that steel jacket—that's what we used in the army."

Bill keeps right on filing, unimpressed. "No, I don't reckon that would tear through many elephants. You see, Frank, that isn't a 'steel jacket' as you call it. It's just a hard cast alloy bullet for small game—that cartridge in your hand—which you call a 'bullet'—is a reduced load I use on squirrels, and the like. Shoots only a little harder than a twenty-two. Gives me a chance to get acquainted with my big game rifle outside the hunting season."

"Heck, that'd be too much gun for me—twenty-two's big enough for anything around here. I've got a peach of a twenty-two. Cost eight-fifty—knocks 'em dead far as you can see 'em—hardest shootin' twenty-two I ever saw. Say, Bill, that reminds me, they's some rust or something in that barrel—I told my kid brother to clean it up last summer, but I s'pose he forgot it. I had it out on a fishin' trip, but hadn't shot it more'n a dozen times. Smokeless, too—I always use smokeless ca'tridges. I'll bring it over an' you can clean it up."

"Thanks!" grunts Bill. "Move around just a little, will you, Frank, so I can get elbow room?"

"Sure! Say what are you doing to that stock anyhow?"

"I'm shaping it up right now."

"Wasn't the shape all right when you got it?"

"Didn't 'get' it—I made it."

"Made it! You mean to tell me you made that stock yourself?"

"Sure, why not?"

"What'd ya make it out of?"

"Piece of walnut like that blank over there in the corner."

"You mean to tell me you carved that out of a chunk of wood like this?"

"Nothing different."

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"Well howd'ja get it that shape?—huh? Howd'ja get that groove cut in for the barrel? Howd'ja get all them other holes cut to fit? Say, boy! You've got more time to waste than I have."

Bill lays down his rasp and turns from the bench. "Frank, you're a pretty good guy—in spots—maybe. But you've a lot to learn. You're missing a lot of fun. Guess you're interested or you wouldn't be asking so many questions. I'll make you a proposition. Our rifle and pistol club meets at the Armory tomorrow night. Come on out with me—meet a bunch of good scouts—learn to shoot a rifle. You'll get just as much fun out of the game as I do—maybe more."

"Nothin' doin' old timer—not for me. Learn to shoot?—hell! I bet I can shoot better'n most of them birds right now;—an' besides I gotta date with a keen frail at the Play-Mor tomorrow night—boy, y'oughta see her. Some rib! Gosh, it must cost you a pile of jack to do all that shootin', don't it? Well, gotta beat it—see you later. Say, Bill—lend me five, will you—I'll pay you Saturday. Thanks! Well, so long!"

And Bill turns back to the bench with a sigh of relief.

* * * * * *

There's the picture—and it isn't exaggerated. In city, town, and country, there are legions of "Franks." We find them everywhere. Slowly, but surely, our male citizenry is becoming emasculated to the point of utter helplessness. Sliding along, content in their weakness, glorying in their inability to do things. Proud of the fact that they've never been taught to use their hands—and blind also, to the fact that they know mighty little about using their heads.

Work—honest, decent labor, skill of fingers, accuracy of eye,—somehow it seems to be beneath the present generation. The business man in his office sticks out his chest, holds "conferences," frowns and looks wise, preening himself on that thing he calls "ability." Then he sharpens his pencil by sticking it into a little machine and turning a crank—or more likely screws down the point of an automatic gold one; has his finger nails cleaned by the blonde in the barber shop; calls a service man to change a tire on his car; wears a little useless penknife on his watch chain and sends it to a grinding shop to be whetted!—yes, he does just that. We've been pampered now to the point of helplessness—and if we don't watch our step, we'll find ourselves at the point of uselessness.

The average man who owns a gun—I said the *average*—takes it to the gunsmith to be cleaned—usually two or three weeks after using it. But the average man of today doesn't own a gun—knows nothing aoout a gun—and brags about his ignorance. "Reform" has done wonders—in the way of making us a race of saps. Not that lack of gun knowledge, or a liking for firearms constitutes a man a sap—but the general trend of the times is doing this

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very thing, and the supercilious attitude of the general public toward those things on which our forefathers builded the nation, is but one of the visible evidences of it.

Back in the hills, or on the farms, conditions are better. Living close to nature gives man a better viewpoint, a keener appreciation of the fundamenta s. People are judged more by their ability than by their appearance or their social accomplishments. The man in the far places is not easily fooled by honeyed words of so called "reformers" who seek to take away our God-given rights; he promptly places him in his proper classification—and in so doing he doesn't call a spade an agricultural implement.

The pioneer of yesterday saw, thought, and acted clearly—with understanding. Having no one else to depend on, he learned to do things for himself. He built h's cab n, fenced his fields, cultivated them with home-made tools, and filled his larder with game which he shot himself—sometimes with a rifle made with his own hands, or by the hands of a neighboring smith, with the crudest of home-made equipment. Civilization, as we know it today, was not essential in his scheme of things.

Since the inception of our nation, the love of firearms has been a natural instinct of the American. Not as a means of slaughter, except in defense of life and property, or to provide food for the table. This her rage has been passed down to us, to be received by some, and rejected by many. Civilization has in some unaccountable manner, twisted our brains.

The pioneer loved his long rifle, and gave it all the care and attention given by the true gun-crank of today—for the pioneer instinct is not entirely extinct. Thanks to the efforts of the National Rifle Association of America, each year finds a greater number who have learned of the wholesome sport awaiting them on the range, and in the woods; while the call of the bob-white and the honk of incoming geese is a perpetual inspiration to those who have inherited a love for the smooth tubes. And try as they may, the sob-sister element will probably never succeed in wholly depriving us of our love for the sport of shooting—for what is bred in the bone is born in the flesh. The male American who scoffs at the sport is either an alien by nature, or else is deliberately perverting his natural ideas.

The arms of the pioneer expressed his individuality—and each was, perforce, a custom bu lt arm. For there were no great factories as there are today, equipped to turn out quantity production. The man who wanted a gun told the smith how he wanted it built, and the smith built it that way. Each gun embodied the pet ideas of the owner—ideas evolved from the necessities of the day and of the locality. As time went on, the private gunmaker was gradually replaced by the factor'es—and firearms began to lose their individuality. Living costs advanced, and with them the cost of material and labor. The machine-made factory rifles were acceptable be-

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cause they were both good, and cheap in price—costing far less than the hand-made muzzle loader—and possessed the advantages of greater speed of fire, greater facility of loading, more compact construction, besides greater power and range.

* * * * * *

Yet in his acceptance of this new arm, the shooter never entirely lost his desire for expression of his personality in his weapons. The evidence is found in the several fancy grades of factory guns still supplied, and which usually are merely stock guns with added engraving and other decoration.

With the growing scarcity of our big game the need for more powerful hunting arms has grown apace, and hunters have learned that the military type of arm, being more highly developed, is now the best adapted to their requirements. So there has come into the field, not a new industry, but the revival of an old one—the building of special arms to the ideas of the individual, on modern actions adapted to the load he desires to use. This industry has been further aided by those, who while still clinging to the traditions surrounding the old "standbys," yet desired certain changes and refinements. Special stocks designed to fit, buttplates with trap for cleaning materials, pistol grips that serve a definite purpose instead of being a mere wart under the shooter's elbow, sights adapted to his eyes, barrels of gilt-edge accuracy, trigger pulls sweet and crisp, instead of reminding one of opening a cash register—these are some of the many things the custom-gunmaker of today is called upon to supply, by shooters who have learned what they want and who can afford to pay for it.

But for every shooter able to buy the gun of his dreams there are hundreds who must count their cash more carefully. And they,—like the pioneer who having plenty of time and little cash, mined and smelted his own iron, felled his rock-maple tree, and built his flintlock,—will retire to their improvised workshop, and with such tools as are available, produce the weapons they want. For failure is not written for the true gun-crank.

* * * * * *

Does home gunsmithing pay? That all depends. It pays Bill, but it may not pay Frank. The man who has the skill, or the patience to acquire the skill, necessary to turn out a job of repairing or remodeling in a workmanlike manner, will be far more proud of his gun than if it were the work of a high priced maker. Then there is the other man located far from factories and gunsmiths—the man to whom a reliable firearm is a daily necessity. A little knowledge of the more common repairs may prove immensely valuable to him, eliminating tiresome weeks of delay with the gun sent to the factory for repairs or alteration, or in saving the price of the job at a time when dollars are few.

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The gunsmith, for some reason or other, has always surrounded himself with an aura of mystery; leading the shooter to believe that his craft was a gift from the gods, not to be encroached upon by ordinary mortals. True, gunsmithing is a highly specialized trade—but there's no black magic about it. It requires mechanical skill, and an understanding of principles, just like any other mechanical trade. Sawing off the end of a stock isn't so very different from sawing off a piece of oak flooring—both require a sharp saw, and ability to follow the line. It's no harder to file a spring or a hammer than it is to file a door latch—and either one may be ruined if you fail to stop in time. The jeweler makes a ring of silver, and oxidizes it—but he thinks the bluing of a gun is a deep dark secret. The dentist makes a gold crown and puts it on a tooth—why shouldn't he also make a gold bead sight and fit it to his rifle?

Many, if not most, of the so-called "trade-secrets" of firearms manufacturers are wide open secrets. The trouble has been that the factories had no reason for telling their customers how to do their own work, and the small amount of data available has been in most cases the work of amateur gunsmiths who, meeting the necessity as it has arisen, have worked out fairly good methods, but not necessarily the best methods by any means.

The man who prides himself on his inability to sharpen a lead pencil may well gasp at the sight of another man—perhaps one who is not a mechanic by trade—making and fitting and checking and finishing a rifle or shotgun stock; or spending long hours filing out some small part that "quantity production" methods would complete in a few minutes; or in bluing a barrel when there are factories better equipped to do it. "Does it pay?" he will ask. Of course not!—not as he would figure it. The gunowner cannot count his time at so much per hour and come out ahead on the job. But, in using his non-productive time to do work that perhaps he could not afford to buy, he acquires beautiful, well fitted and finished and smooth working arms that are a constant source of pride and satisfaction, because products of his own handiwork—expressing his own individuality. So of course it pays him to do it.

Gunsmithing is not child's play. It is hard, slow, painstaking WORK, calling for reasonable skill, the proper tools (many of which may be home made), and a whole lot of patience and attention to small detail. Yet it is perhaps the most fascinating pastime in which a shooter can indulge, next to the actual use of his weapons in the woods or on the range, affording him the opportunity of having exactly what he wants, at a price he can afford

* * * * * *

Yes—home gunsmithing pays; it pays in more ways than one.

Chapter 2

THE GUN-CRANK'S WORKSHOP

THIS chapter is not intended for the professional gunsmith. It is written mainly for the sportsman who is desirous of providing a place wherein he may tinker when he pleases and as he pleases, with a view to steering him in the right direction. The man who tries to do his gun tinkering on a corner of the kitchen table is placing himself under a handicap right at the beginning; and while the "cliff dwellers" residing in city apartments may be forced to do thus, the man who has a bit of space to spare in his house will find it pays big returns in satisfaction and convenience to rig up a regular shop.

But in consideration for those not so fortunate, we had better consider their needs for a moment. Because a man "batches" in a furnished room, or lives in a kitchenette is no reason for depriving him of all the pleasure which the true gun-crank derives from working over his pets. A few simple tools with a compact chest or drawer to keep them in will give him many an hour of profitable pleasure.

THE "TABLE" LAYOUT The first tool or piece of equipment to be considered in any case, is the vise. Without a good vise even the best mechanic is pretty helpless. The man who must do his work on the kitchen cabinet or library table must use a vise that can be clamped on or removed at will; and it should be a good one, with accurate steel jaws—none of the two-bit cast iron affairs found at the local department store, although even this kind is better than none. The Goodell-Pratt bench vise No. 161 has 2 inch jaws, opening 2 inches, and weighs 3 3/8 pounds, costing $2.60 list. It clamps firmly to any table top by a strong wing nut. The local hardware dealer or your favorite mail order house either has it or can get it for you on special order. It is a real vise made for fine small work. Another which will be even more useful at times is the little Yankee toolmaker's vise with swivel base, No. 1992. The

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jaws are 2 inches wide and 1 1/4 inches deep, opening 1 15/16 inches. The vise may be turned around to any position or angle and firmly locked in position. The jaws are straight, of hardened steel, with extra false jaws notched for holding round and irregularly shaped stock. The base of this vise fastens to the table with screws, but it may also be fastened to a small piece of hardwood which can be fastened to the table with hand clamps. This vise costs $7.50 and is worth it. A smaller size may be had at $5.00.

In addition to the vise or vises, you should have a good sized piece of board that can be placed on the table to work on. Both housewives and landlords are averse to having the furniture marred up with tools.

The Starrett No. 166-B pin vise is a handy thing for holding small rods and pin stock for filing. It has a small close fitting chuck, and is held in the hand while in use. It takes any size rod from .030 to .062 inch, and costs seventy-five cents. The No. 166-A is the same price, taking all sizes from 0 to .040 inch.

A hacksaw with 12 inch blades, and a few files, two or three pairs of good long nosed pliers, stones for lightening trigger pulls, and half a dozen screw-drivers will enable the table worker to do a lot of tinkering when the evenings are long and the story of the latest murder is missing from the evening paper. Under such circumstances heavy work such as making stocks is of course out of the question, but there is nothing to stop one from refinishing his stocks. A man might even be able to do a job of checking, by clamping the checking cradle to the table top. (See Chapter 12 for description of checking cradle.)

THE WORKSHOP. Now for the real home workshop, possible for the man who lives in a house, or in some cases for the apartment dweller who can arrange for a little basement space. Somehow it seems the natural thing to put the workshop in the basement—yet this is the worst place for it, and should only be used in event no other space is available. Basements are seldom well lighted, and are often damp. Constant watchfulness is necessary to prevent tools, guns and parts from rusting. Cement workers have preparations for damp-proofing basements which are very effective, and it will usually pay to have this done; or one can buy the material and apply it to the walls himself. Select a spot having as much daylight as possible and with good ventilation. North light is best in any shop; but since much of the work will probably be done at night, good artificial light is also essential. Acetylene or one of the powerful gasoline lamps or lanterns provides an excellent light in the country where other means of lighting are not available. If one has electric light, one or two drops should be placed directly over the bench in position that will eliminate shadows on the work, and 75 watt "daylight" mazda lamps should be used. These give a very brilliant light that is easy on the eyes.

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The attic often presents splendid possibilities for the home workshop, and its only drawback is that most attics are insufferably hot in summer. But for that matter most of us prefer to spend our summer evenings otherwise than working. The long winter evenings afford the best times for tinkering. The garage or woodshed or other outbuilding may often be converted into an excellent workshop. The cracks should be well battened to keep out cold, and the roof put in good repair. It doesn't pay to let rain drip on high grade tools. A dirt or cement floor is usually damp and uncomfortable—a substantial wood floor is the best of all. It should be solid, well supported underneath, and without gaps and cracks to catch dirt. Be sure there is plenty of light and ventilation, and some means of heating in cold weather. Kerosene or gasoline heaters are inexpensive and may be purchased from the mail order houses at small cost. The Sunshine Lamp Company of Wichita, Kansas, makes a splendid low-priced gasoline pressure heater which is safe to use, and economical in fuel consumption. An old wood or coal stove is the best, provided there is room for it, but a discarded kitchen range, if in usable condition, is probably the best of all. For in addition to providing heat, it is also excellent for melting bullet metal if one happens to be a handloader, and by taking off the top lids it can also be used for the bluing tank or the nitre pot. If one expects to do much bluing in the home shop, it will often pay to install a three or four burner oil or gasoline range for heating the tank, in case city gas is not available.

If oil or gas is used for heating, be sure to have good ventilation in event there is no flue connection in the shop, for these heaters use up oxygen very rapidly making the air foul and unhealthy to breathe. If the shop has a good flue, and you can afford the cost, by all means install a small portable forge and anvil. It will pay for itself many times over in the making of tools, bending of parts in making alterations, in brazing, welding, and countless other operations. You need not be a blacksmith to use a forge to good advantage. Small portable forges and anvils, with necessary tools, can be purchased from the mail order houses all ready to set up. The forge should by all means have a metal hood over it to carry off gas and chemical fumes. A cheap castiron anvil will answer for much of the work—most of it, in fact—although of course a good steel faced anvil is best if you can afford it.

The very best shop of all, provided one desires to do bench work only, is the unused room found in most large homes. Usually this is a small room not convenient or well adapted to other uses, and the purchase of a new dress or hat for friend wife will often effect the arrangement without difficulty. Here may be built in, a gun cabinet, with shelves and cabinets for loading materials and supplies, and all the paraphernalia which the crank usually has kicking about. A room right in the house is likely to be well lighted and warm and

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comfortable, and if the shavings, etc., are religiously swept up and carried out after each seance at the bench, the likelihood of domestic storms is reduced to a minimum.

Having everything else decided and arranged, the most important consideration of all comes next—THE WORK BENCH. It may be built, or purchased ready made—but it must, first of all be substantial. A flimsy, wobbly bench is as bad as no bench at all. The top should be at least 1 3/4 inches in thickness, and the legs heavy enough to support it firmly. The legs must be firmly braced underneath to prevent wobbling and the entire bench must be heavy enough so that it will not shake under heavy sawing or draw-knife work.

From four and one-half to six feet is the best length; eighteen to twenty-four inches is plenty of width, and the height may be from 30 to 36 inches, or even higher, depending on your build and whether

you use the bench mostly sitting or standing. My own choice is unusually high—39 inches; and my height is five feet seven; but I like to have the work up in front of me so I can handle it without strain on neck and back. Even with a rather high vise mounted on top of the bench I do not find this height too great. Most of my work is necessarily done standing, and a 36 inch stool provides a comfortable seat when the nature of the work permits. If one is interested only in very small work, such as making sight parts, or something of that sort, a very low bench—28 to 30 inches high—with a small low vise should be selected. Then a good comfortable chair with a back, and away you go. Such an arrangement is usually found in shops where much assembling of small parts is done.

An excellent home-made bench may be built from 2 inch pine lumber, using the Hallowell Steel Bench Legs sold for this purpose. A set of these legs for a bench 33 1/2 inches high and 28 1/2 inches wide will weigh 30 pounds, and cost about $6.75, complete with bolts, screws, etc., ready for assembling to the home-made top. Two or three dollars worth of lumber, a set of these legs, and three or four hours' work will result in a bench that cannot be surpassed for strength and rigidity. There are no drawers for tools, but these can be made and fitted by anyone handy with carpenter tools at small additional cost. Steel brackets for attaching a backboard to be used as a tool rack can be had for 35 cents each. These legs can be purchased from the Ellfeldt Hardware and Machinist's Supply Company, Kansas City, or from any larger dealer or jobber, most of whom either catalog them or carry them in stock.

The manual training benches carried by Hammacher, Schlemmer & Company, New York City, are rigidly built, with thick maple top, and fitted with a quick-acting cabinet maker's vise. A good bench of this type with drawers for tools and supplies will cost in the neighborhood of fifty dollars, and it is worth the cost if you plan to use it a great deal.

11.

The frontispiece shows a special bench which I had built in a mill at a cost of about fifty dollars. The upper tool drawers have sliding compartments for small tools, parts and supplies, while the sloping rack on top places the chisels, screwdrivers, and other tools used most frequently, in convenient reach. When doing stock work it is essential that the chisels are all within reach, as one is using first one, then another. Each size and shape should have its own location, and should be put back in the rack when another is taken. Thus there is no delay from misplaced tools. A simpler arrangement almost equally effective is a backboard eight or ten inches high, with a leather strap nailed on in loops for the different tools. Each should have its particular place, and be kept in that place at all times when not actually in your hands.

STORAGE OF SUPPLIES. Back of the bench, or conveniently located at one side, there should be shelves or cabinet for supplies, tools and materials. The important thing is to have a definite place for everything you use, and keep things in their places at all times. Tools should be kept where they are readily accessible—either on the tool rack, in drawers or shelves, or hanging on the wall above the bench. Don't "bury" things. The old-fashioned tool cabinet or chest in which the tools are packed and piled is a most infernal nuisance. Keep everything in plain sight as far as possible, and what can't be kept in view should be in containers that are plainly labeled.

For example, screws. The usual plan is to keep them in boxes stored away in shelves or cabinets, and the worker generally has to open a dozen or so boxes before finding what he wants. I use the small screw-top glass jars in which salad dressing is sold by grocers. Dump an entire box of screws into the jar—one jar for each size and kind—stand the jars in rows on narrow shelves, and you can put your hand on the right one instantly. A small sticker pasted on each jar also gives the size and thread.

This stunt is especially useful for special screws for sights. A few extra sight screws can be put into the jar, with a label showing the sights the screws are intended for. The drills and taps for these screws are kept right in the jar with them, hence always at hand when wanted—no hunting. Sights, springs and other small parts can also be kept in jars and plainly labeled to show what they are.

Besides tools, which will be discussed in the following chapter, there are two other essentials to the well ordered home workshop. These are a good bench brush and a broom. Keep the place cleaned up! A litter of shavings and dust on bench top and floor is not only unhealthful, it is conducive to accidental fires, and worst of all, a screw or other part dropped into the litter is almost sure to be lost—often resulting in weeks of delay while another is secured from the factory. And if it happens to be a part of an obsolete gun for which parts are no longer available—wow! It's a lot cheaper

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to sweep out occasionally than to pay a machine shop $1.50 to make a screw.

SHOP LAYOUT. Arrange things in the shop in the most convenient manner possible. Saving of steps means more and better work in less time. The cabinet maker's vise, if one is used, should be placed at the extreme left end of the bench. Most gunwork, however, requires a regular machinist's or iron worker's vise—and the best place for it is near the right end. By all means, if you are right handed, have the left end of the bench in the clear. If necessary to set it in a corner, let the right hand end be inaccessible rather than the left. If you go in for a drill press, lathe, forge, or similar equipment, get them clear of the bench—on the other side of the shop if possible. Five or six feet of floor space in front of the bench will be needed, and the same amount at the left end.

Bluing equipment should be in a separate room, away from the tools if possible. Bluing is a rusting process, and the steam and vapors are hard on tools. If your shop is in the basement, set the bench and tools in one corner, and the bluing layout as far away as possible—and always have plenty of ventilation when bluing to carry off steam, fumes, and moisture.

Finally, arrange to keep others away from your shop and tools. If in a separate shed or outbuilding, put bars on the windows, and good locks on both windows or doors. If in a basement, it will pay you to partition off the shop with framing covered with heavy wire, and a good padlock for the door. This of course will not keep out a burglar, but it will prevent the sponging neighbor who never has a tool of his own from borrowing from friend wife while you're away, or the gas-meter man from picking up your micrometer,—and it will also keep the lady of the family from helping herself to your hacksaw to cut a ham bone, or using your favorite chisel to chip ice for dinner, or driving a nail to hang a picture with your pet Pope bullet mold. I happen to know how these things go!

If there are children in the family it is essential to keep them away from tools and other equipment during your absence. A small boy who is inclined that way can wreak untold damage in a few minutes time—leaving tools about the yard, or losing them about the neighborhood. Moreover, if you keep powder and primers on hand, the locked door is a necessary precaution.

All this work and fuss and equipment may sound like a large order to the chap who never takes the trouble to tighten up a sagging screen door; but an investment in a small home shop, with good dependable tools, will pay big dividends in satisfaction and pleasure to the true gun crank, besides providing a sure means of keeping the kids in off the streets as they grow up and begin to take an interest in the "old man's" playthings.

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Chapter 3

TOOLING UP

HAVING prepared a place to work, whether in basement, attic, or out-building, the next consideration of the gun-crank is tools and equipment. It is possible for the amateur gunsmith to accumulate several hundred dollars worth of tools in a few years without realizing it, simply buying this or that item as needed to complete a job; and when expensive tools are bought, used once, then laid away and forgotten, one's hobby can easily become a gross extravagance. Unless you expect to use a tool frequently enough to make the investment pay, better look for a way to do without it, and use its cost for a more practical purpose—such as buying ammunition or loading supplies. I do not mean by this that a man should hesitate about buying first class tools whenever needed, and whenever they are of a type to serve a real need. It is poor economy, for example, to pay $1.40 for a counterbore reamer to cut a hole for some particular screw head on an obsolete gun; the screw is probably a bastard size which will never be encountered again. Rather, adapt another screw, or if this cannot be done, spend a few minutes making a

flat reamer which will cost you nothing but your work, and which will do one or even several jobs successfully.

This economy may of course be carried to the opposite extreme. No man deserves credit for sponging or borrowing tools from his neighbor, nor for using some nearly worthless makeshift and cobbling up his job. Every job should be turned out in the most careful, painstaking manner of which you are capable—and most men are capable of better work than they think they are. The difference between a good job and a poor one quite often depends on knowledge of some simple "kink" to obtain desired results. A man may scratch his head and study for hours on some simple mechanical problem, when the answer is right before him. Learn to do things right; learn

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the tools needed for each job; and if the job is likely to recur frequently, the purchase of the tools will always prove a good investment.

A large initial outlay is not necessary for the gun crank starting a home workshop. A few simple tools, of best possible quality, will do to begin with; others may be added, or perhaps made, as the need arises. Thus in the course of time your equipment becomes more complete, and many a job that would have stumped you in the beginning will seem like child's play, because you are molded up for it.

FILES. If I were forced to start a shop with but one tool, that tool would certainly be a file, provided I had my choice. I consider the file the most important of all mechanical implements; with it many other tools can be manufactured, and in a pinch it could be made to serve, after a fashion, in lieu of other tools.

Next to a tool with which to work, a method of holding the work is most important—so a first class vise becomes a secondary consideration. With a good file and a good vise, a "fair to middlin'" mechanic need not be afraid of many jobs. So we will first consider files—both wood and metal—and vises at some length, after which we will discuss other tools likely to be needed by both the amateur and professional gunsmith.

The file in one form or another can be traced back almost to the beginning of time. While its development probably followed that of the saw, its greater scope of usefulness entitles it to a higher place in the history of civilization. Abrading instruments date back many centuries prior to the Christian era, and like most other man-made tools, had their origin in nature. The following, quoted from "The File in History," published by Henry Disston & Sons—a little book which every mechanic should have and read, by the way—is interesting:

"There is a type of mollusc having a rough tongue with which it rubs or files through the shells of other molluscs on which it feeds. The wasp, also, has a rasp-like organ with which it abrades dry wood, afterwards mixing the dust with a glutinous saliva to form the paper with which it builds its nest. The cat's tongue, and that of the cow, are familiar examples of abrading organs in the animal kingdom.

"Prehistoric man made handles for his weapons by sawing or splitting wood, rough shaping the pieces as well as he could by primitive methods and finally finishing and polishing them by means of the particular abrasive material found in his vicinity. * * * To abrade, or file, ancient man used sand, grit, coral, bone, fish skins, and gritty woods—also stone of varying hardness in connection with sand or water.

"The Egyptians of the Light Dynasty, about 1200 to 1000 B. C. made small rasps of bronze, as several specimens have been found which could be more or less accurately connected with that time. * * * That there were iron files in Solomon's time may be inferred from his statement: 'Iron sharpeneth iron; so a man sharpeneth the countenance of his friend,' but the first historical mention of artificial files that can be definitely identified as referring to such implements as are now understood by this term is found in I Samuel: xiii; 21, which is supposed to relate to about the year 1093 B. C.

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"'They had a file for the mattocks, and for the colters, and for the forks, and for the axes, and to sharpen the goads.'

"Files are also mentioned in Homer's Odyssey. They were doubtless very crude in form and inefficient in operation as compared to present day files, but the fact that they were mentioned in these early writings is proof that they were held in high esteem by workmen of ancient times."

And by workmen of today also, I might add. Your real mechanic prizes his files, and gives them good care. He doesn't throw them loose together in a drawer, to blunt and break the teeth, but lays them carefully on the bottom of drawer so they cannot rub together.

Until comparatively recent times, files were made entirely by hand. The workman held a chisel above the soft annealed blank at the proper angle and struck it repeatedly with a mallet, cutting and raising the teeth as required. On some of the old handmade files the spacing is almost as even and perfect as on the best modern machine made files. Even to-day there are Swiss file makers who still use the old method of hand cutting, and their files are world famous for their quality and temper.

The three best brands of files in this country to-day are the American Swiss, the Nicholson, and the Henry Disston. Every file turned out by either of these firms may be considered a good file; if used for the purpose intended. Of the three, I find the American Swiss most useful in gun work—not that the quality is any better, perhaps, but because this firm produces a larger variety of special shapes and sizes than either of the others. All three makes can be procured through any first-class dealer or jobber, and it will pay the aspiring gunsmith to secure the factory catalogs of all three companies and study them,—it is surprising how many shapes will be found that one did not know existed. Files—even the best of them—are comparatively cheap in price; it pays to have plenty on hand—plenty of shapes, plenty of sizes, and plenty of different cuts. By "cut" we mean the size and formation of the teeth.

Files are usually divided into three general classes—single cut, double cut, and rasp cut. The single cut has straight single teeth running at a slight angle across the blade. The files are called, according to the size of these teeth, "Rough," "Middle," "Between Middle and Bastard," "Bastard," "Second Cut," and "Smooth."

The double-cut file is cut in the same manner, but has another set of straight teeth cut diagonally across the first, resulting in short pointed teeth. All double-cut files are usually referred to in the shop as "bastard" files whereas the term really applies to the size of the teeth, whether of single, double, or rasp cut.

The rasp tooth is cut in a different manner from the other two. Each tooth is cut separately by a blow from a pointed chisel. The commercial names for the different size teeth are: "Horse," "Rough," "Middle," "Bastard," "Second Cut," and "Smooth."

Files and rasps are further subdivided and named according to

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their shapes and uses. Figure 1 shows the sectional shapes of several of the most commonly used.

These are but a few of the many special shapes available for special classes of work. In addition to files and rasps there are "rifflers"—very small steel handles with specially shaped and curved ends with teeth only on the ends used by die-sinkers and silversmiths, and also wood rifflers, called "wood carver's rasps," but made similar to the smaller rifflers, except for the size and teeth. I would consider the following a sufficient file assortment for the amateur gunsmith to begin with—later, as he comes to appreciate the many uses of files, he will study the makers' catalogs and select others as needed:

1	Cabinet rasp, rough or middle, for roughing out stocks,	14	inch
1	Cabinet file, double-cut bastard, for final shaping, half round,	14	inch
1	Half round, double-cut bastard file (for metal),	14	inch
1	Half round, double-cut bastard file (for metal),	10	inch
2	Vixen files,	12	inch
1	Single cut mill file, second cut,	12	inch
1	Single cut mill file, smooth,	12	inch
1	Single cut mill file, smooth,	8	inch
2	Single cut mill files, smooth,	6	inch
1	American Swiss Finishing or Stripping file, No. 4 cut	12	inch
1	American Swiss Pillar file, Nos. 2, 3, or 4 cut	12	inch
1	American Swiss Pillar file, No. 2 cut, narrow	3/8 by	8 inch
1	American Swiss Pillar file, No. 2 cut, extra narrow	5/16 by	8 inch
1	American Swiss Pillar file, No. 4 cut, extra narrow,	5/16 by	8 inch
1	American Swiss Crossing file, No. 1 cut,		8 inch
1	American Swiss Crossing file, No. 4 cut,		6 inch
1	Screw slotting file.		
1	Double-cut rattail file,	3/8 by	12 inch
1	Double-cut rattail file,	1/2 by	12 inch
1	Double-cut rattail file,	1/4 by	8 inch
1	Straight round file, No. 2 cut, (Am. Swiss),	3/16 by	6 inch
1	Straight round file, No. 2 cut, (Am. Swiss),	5/16 by	8 inch
1	each of the following die-sinker's needle files, 6 inch: Round, Square, Knife, Flat, Three-square, Crossing, Half round, Barrett		
3	each die-sinker's needle files as follows, 4 inch Round, Knife		
6	3-square Escapement files, No. 2 cut,	5-1/2	inch
1	each die-sinker's rifflers, Nos. 1, 3, 4, 5, 11, 16, 18.		
1	each Hammacher-Schlemmer Co.'s. wood carver's rasps Nos. 140, 142, 146, 148, 152.		

This sounds like a pretty large order; yet the entire layout need not be bought at one time, and even if it is, it will not run into a great many dollars; and every tool in the lot is extremely useful—many being absolutely necessary. Where several sizes of the same

kind of file are listed, it is advisable to buy only the one size needed for the particular job in hand, adding the others as needed. With such an assortment, or even half of it, a man will be pretty well equipped to turn out any kind of filing job required for the alteration or manufacture of any gun part that can be made by hand. The rifflers and wood carver's rasps can be passed up if desired—they are extremely useful, but not always essential. All of the larger files will be needed frequently, and most of the die-sinkers. The finishing or stripping file and the large pillar file will be found indispensable for

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striking barrels, and should be used for no other purpose. Various others are mentioned from time to time in connection with special jobs described throughout this book.

Having the files, the next thing needed is a file card—a brush with short hard steel bristles with which to brush out the filings that stick in the teeth. A clogged or "pinned" file is very quickly ruined, and a 40 cent card will add months or years to the life of all your files.

THE VISE comes next. The most useful of all vises in the gun shop is the Prentiss Ironworker's Vise No. 19. This vise costs about $15.00 and is the best investment you can make if you

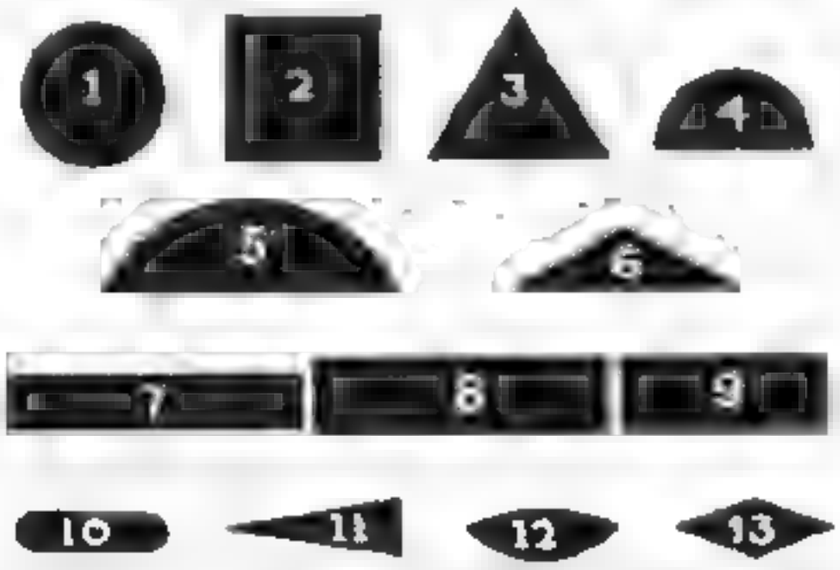

Fig 1. Various sectional shapes of useful files, and their names: 1. Round; rattail, mousetail (according to size) made in both taper and parallel. 2. Square. Taper and parallel. 3. Three-square. Taper and parallel. 4. Pit-saw; really half round in section, but not so named. 5. Half round. 6. Cant or lightning. Same shape as a Barrett file except the latter is slightly thinner, and smooth on the angled sides. 7. Mill. 8. Flat. 9. Pillar. 10. Round edge joint. 11. Knife. 12. Crossing. 13. Slitting; lozenge.

plan to do much work. Both the base and one jaw are swiveled, enabling the worker to swing the vise to any position or angle, and to grip tapered stock, barrels, gunstocks, etc., firmly. The jaws are 3½ inches wide and open 4¼ inches, fitting together very accurately when closed. If you do not care to put this much money in a vise, then get a heavy, cheaper iron one of about the same size—they can be had as low as five or six dollars, and often can be picked up second hand for half that amount.

For a second vise it is well to consider one of the rapid-acting cabinet makers' vises which attach under the bench, the jaws coming flush with the top. These open and close by a quarter turn of the handle, and are fine for planing and draw-knife work, but are no good for heavy work on metal. They can be had from any hardware or mail order house and cost around $5.00.

For a third vise, consider the little Yankee No. 1992 toolmaker's vise mentioned in Chapter 2. It is worth its weight in gold for small jobs on sights, springs, pins, etc., and has the advantage of being

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detachable from its base, so that, with small work in the jaws, it may be clamped at any desired angle in the larger vise. Any of the Goodell-Pratt hand vises, and a G-P or a Starrett Pin Vise will also prove useful occasionally.

SAWS AND PLANES. Now we need a few wood working tools. Some of these will—or should be—found about every well ordered household, so they need not be charged against gunsmithing. First a rip-saw and a cut-off saw, of either Disston or Atkins Silver-Steel make—it pays to buy nothing but the best saws. A ten or twelve inch back saw for use in the mitre box for sawing off butts, and other accurate work will prove valuable, but may be dispensed with. Same with the mitre box. A good Stanley or Langdon iron mitre box is worth its weight in gold—when you need it; you don't need it often. A common wood mitre box such as every carpenter makes for himself in a few minutes, will serve nearly as well.

You should have three good planes—jack, smooth and block. If you want to buy only two, cut out the smooth. Stanley's Bailey pattern iron planes are the best ever sold and well worth the difference in their cost over cheaper ones. Such tools as planes, saws, etc., will find many uses other than in the gun shop, so there is economy in buying good ones. For a jack plane the Bailey No. 5 1/4 at $4.50 will answer your purpose nicely; the No. 1 smooth plane at $3.55 will also be handy for smoothing up the sides of stock blanks, but the jack will answer nearly as well; for the block plane, give first choice to the Stanley No. 65 at $3.40, second choice the Stanley No. 65 1/2 at $2.80, and last, the Stanley No. 110 at $1.25.

Many stockmakers use A DRAWKNIFE for the first shaping of a stock, working it down almost to size before using the rasp. I have a drawknife which I seldom use; nor do I often recommend it to the amateur stocker. Most of my stocks are made from curley or figured wood which will not shave worth a cent, and it is nearly as quick to use the round side of the cabinet rasp, which takes off the surplus in a surprisingly short time. Moreover, nobody ever split a stock or took off wood unintentionally with a rasp. Occasionally I find a drawknife helpful on a straight grained piece for roughing off the corners, but I could get along nicely without it.

The same applies to THE SPOKE-SHAVE or shake-shave. If the wood is perfectly straight grained, this is a mighty handy tool for shaping up following the drawknife. Yet a good rasp will do the work quicker and easier, for me at least, and my spoke-shave usually rests comfortably in the drawer with the drawknife. No objection whatever to using one if you are familiar with it and like it—only, remember it leaves flats on the stock which must be removed later with the cabinet file and sandpaper.

One tool which I have never used that might have saved me a little time, is a rabbet plane or a router plane. Such a tool is handy for roughing out the barrel channel in a stock, provided you keep at

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least 1-16 inch from the sides and bottom. The barrel channel is seldom or never a straight groove—most barrels being tapered or having some special formation. Perhaps one reason I have never used the rabbet plane is because so many stock blanks are twisted or warped out of shape in the drying so that the channel is seldom cut parallel with the sides, but is centered on a line which likely as not runs at a slight angle with the piece. Use a rabbet plane to hasten the job if you want to—but leave plenty of wood to be finished out with the chisels as described in Chapter 10. These planes are made

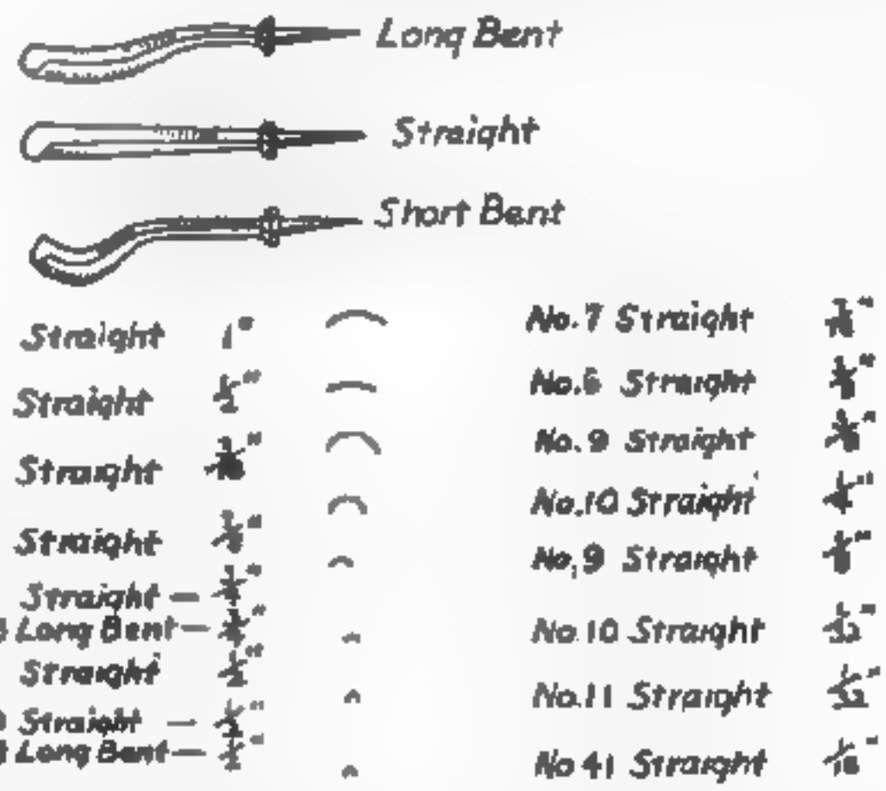

Fig. 2

by Stanley, and are listed in all hardware catalogs, also handled by the large mail order houses.

CHISELS. The most important tools used by the stockmaker are his chisels. Without good chisels he is helpless. And while the ordinary socket firmer chisels and deep thick gouges used by carpenters may be used for inletting a stock, their work is crude and proceeds very slowly compared with the work of the thin, keen carving chisels, which are made in a wide variety of shapes and sizes.

The very best carving chisels in the world are those made by J. B. Addis and Sons, of London. They are as far ahead of common

chisels as a Packard is ahead of a 1913 flivver. They are thin and springy, made of fine Sheffield steel, forged entirely by hand—they are *real tools*. Addis chisels are sold in this country by Hammacher, Schlemmer & Co., New York City, who publish a tool catalog that should be in the hands of every gun-crank, and in this catalog they list a large number of shapes and sizes in which these chisels are sup-

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plied. Figure 2 shows the three shapes of blade—straight, short bent and long bent; also the edge shapes and sizes that will prove most useful to the stocker. These chisels do not cost a great deal more than the ordinary kind. They should be ordered with hexagonal maple handles already fitted.

When you get the chisels they will be ground on one side, but not sharpened on a whetstone. This you must do yourself, and instructions for sharpening will be found in Chapter 7.

For your first attempt at stocking a gun you can limit your purchase to two or three chisels, choosing the shapes that seem to fit the cuts in the old stock best. Later, you will want to add to your chisel collection. Never try to use a hollow chisel that is the full size of the channel to be cut—the chisel should invariably be a size or two smaller.

Saws, planes, drawknife, chisels, rasps and files—these are the essentials of the stock maker. Many others will come handy at times, and can be added when and if required. Don't blow all your cash on tools with which to make the gun, and have none left for "shootin' money."

I have not mentioned the mallet in connection with the chisels, for the very good reason that the mallet may very nicely be dispensed with. Use it if you like, but use it seldom. Stocks are not inletted by hammering or driving in the chisels. Wood carving chisels are held in the hands, and a mallet blow is seldom or never required. The tools must be kept so sharp that they will cut across the grain of hard walnut readily without hammering. An occasional light blow with mallet or side of hammer may be excused when cutting the magazine mortice, but nowhere else. The stock maker trims out the wood in shavings instead of gouging it out in chunks like a carpenter morticing in a door lock. There's quite a difference.

Carving chisels are "chisels" and not "gouges" whether they are curved or flat, and their sole purpose is *cutting*. Select your chisels by number and shape of edge—and do not be led into buying a "set" of carving tools put up in a box. Most of them will be useless for gun work, and the box is a nuisance anyhow. Get the chisels up in a tool rack where you can get at them.

BRACES, BITS AND DRILLS: A good brace and a few bits will be required for boring holes. The principal use of augur bits is in roughing out wood in magazine mortices, and in boring out the butt recesses under a butt plate trap. Augur bits are not expensive, and it will pay to invest in a set of high grade ones, graduated from ¼ inch to 1 inch by sixteenths. An expansive bit may be needed now and then, but there is no need of buying it until the need arises.

Forstner bits are very useful in gun work. Unlike augur bits they have no spur in the center, being guided by a sharp outer rim or cutting edge, and making a hole with a smooth level bottom.

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These are very convenient for cutting down into the ends of lock recesses in side lock shotgun stocks, and elsewhere, but since they cost two or three times as much as augur bits, it is advisable to purchase them one at a time as needed. These bits are often incorrectly called "Foster" bits, so it is well to know both names in case the hardware man doesn't know what you're talking about.

A Yankee push-drill with an assortment of small bits in the handle is a handy tool around the home—but about the only thing you will ever use it for is to drill screw holes in the butt of a stock, and for this purpose a hand drill or breast drill is better. Though generally used for metal work, these often come in handy for woodwork as well. They should be selected with care, and the cheap ones avoided, as they are not accurately aligned, nor can the chucks be depended upon to hold the drills. The hand drill chuck should be capable of taking drill shanks up to 3/16 inch in size, while the breast drill should take them up to 1/2 inch. Any of the Yankee, Goodell-Pratt, or Millers Falls drills are good—select the model you like best and you will make no mistake.

MEASURING TOOLS: A good boxwood marking gauge will be needed for running the center line around stocks—provided the sides of stock are planted perfectly straight. Otherwise the gauge will have to be replaced by a pencil and long straightedge. A narrow bar of flat hardened tool steel makes the best straightedge of all. The other measuring and marking tools you will need are: a 12 inch steel scale, a folding wood or steel rule 3 feet or longer, sharp pointed dividers, inside and outside calipers. A pair of hermaphrodite calipers will pay dividends on many a job. These have one leg pointed and adjustable for length; the other leg is bent, and the hinge joint has no stop so that the bent leg can be used on inside or outside measuring, while the pointed leg is used for marking.

Thus far I have mentioned no machinery. The average man does not care to go to the expense of it for a little home tinkering, nor does he have the amount of work to warrant such expenditure. The only time any sort of machine is really essential to the home tinkerer, is when he has fitted a recoil pad to a stock. The only way the pad can be dressed down even with the stock is on a flat sandpaper wheel. For this purpose I use a Van Dorn motor grinder of 1/4 h. p. with the grinder wheel on one end of shaft replaced by a 7-inch wood wheel 1/2 inch thick, on which is glued a sheet of garnet cloth. This motor runs at 3600 r. p. m. which is really faster than a sandpaper wheel should run—2500 would be a better speed and easier to handle. The high speed is of value when using a coarse grinding wheel to rough off metal, instead of filing or milling it off.

A small wood turning lathe, while not a liability, is seldom needed by the stocker. Now and then it would help on some small job, such as turning up dowells, or something of that sort—but don't

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put your money in a wood turning lathe until you have everything else you ever expect to need.

The tools for metal work of the amateur or the professional gunsmith are far greater in number than the woodworking tools. After the vise and the files, the most important are perhaps the SCREWDRIVERS. I doubt if any tool is more often abused, or more grossly misunderstood than the humble screwdriver. The average man tries to get along with one or two, when he needs a dozen. Gun screws are often set in very tightly at the factories, and their removal necessitates a driver that exactly fits the head slot both in width and thickness. Unless it does so fit, the attempt to remove it usually results in a badly marred screw head—maybe one that is engraved and color-hardened, and must be sent to the factory for replacement. A poorly fitting driver may even split off half the head—then the fun begins! As soon as the air clears it is necessary to drill out the screw, which commonly results in ruining the threads in the hole also.

It doesn't make much difference what make screwdrivers you buy—they all have to be shaped up after you get them. I like Yankee drivers best, but probably this is just a habit. Select sizes a trifle larger than the screw slots most commonly encountered. File the end of blade off perfectly square, then thin it down on the sides, *without beveling*, until it is just an easy fit in the slot. File to correct width, and round the side edges slightly at the point. Leave the "business end" square and sharp, unless you run into a screw having a milled slot rounded on the bottom from side to side—then round the edge of driver slightly to fit it.

For removing the tang screws from Springfield and other bolt action rifles, I have a screwdriver with a large heavy handle from which the blade projects only two inches. This little devil gets right down to business and takes 'em out! The handle is thick enough for a good grip, and the hand is brought so close to the work that there is no danger of slipping. An extra large long blade will be needed for getting at the stock screw that is put in through a hole in the butt as in the '99 model Savage and the Lee Enfield. Between these two you will require various sizes that may be purchased or made as required. The main thing is to have the right size for the screw in every case, and don't try to make the wrong size do. Either make a new one outright, or grind down another to fit—and be sure the point is well hardened, but not too brittle.

Screwdrivers are easy to make. A few pieces of drill rod should be on hand at all times for this purpose. Heat the end of rod and forge it flat, then file to shape, or grind; then harden and temper as described in Chapter 21. If you have no drill rod or other tool steel, make the blade of cold rolled steel and caseharden in cyanide—

some of the best screwdrivers I have are made thusly—and this is a good remedy also for the cheap "store" ones that prove too soft.

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The sides of most screwdriver blades are tapered slightly toward the point. This is O. K. provided the blade does not have to reach into a hole for the screw—in that case grind off the taper so that the blade is slightly wider at the extreme point.

A small jeweler's screwdriver with revolving head should be on hand for removing the smallest sight screws, and the little all steel screwdrivers packed with Colt revolvers are also excellent. When making very small screwdrivers, use drill rod and shape the point as shown in Figure 3, using a rattail file for the purpose. This is the strongest possible shape for a small blade. When made of

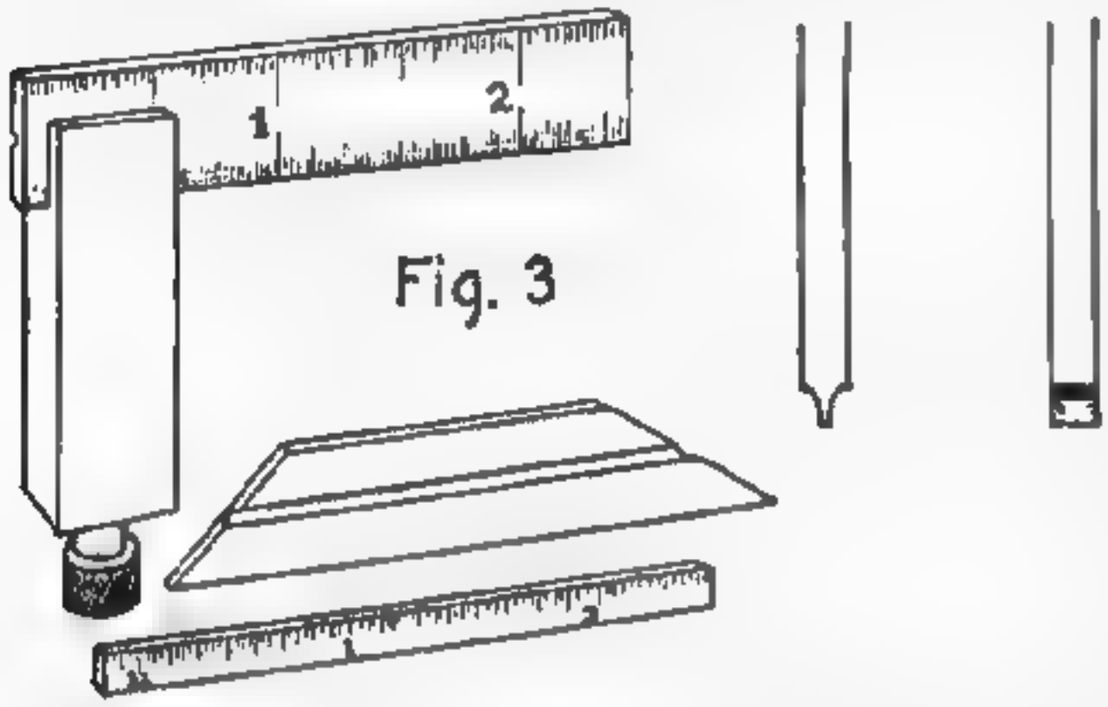

Fig. 3

tool steel without heating or forging, it is seldom necessary to harden or temper the point.

BENCH DRILLS: Hand drills and breast drills have already been mentioned. A small drill press is useful, but hardly worth the cost in the home shop. The gunsmith should have one, motor driven, taking drills up to one-half inch in size, or larger if his work requires it. A good bench drill is exceedingly useful, and some models cost little more than a high grade breast drill. The Goodell-Pratt No. 8 1/2 drill takes up to 1/4 inch drills in the chuck; it is hand driven and hand fed, and is equipped with a special vise which can be used in place of the table for holding work. The price is $11.55 list. The same drill without the special vise is known as the No. 8 and lists at $8.50.

The No. 9 drill of the same makers takes up to 3/8 inch drills and has a table adjustable for height. It is also hand operated, and lists at $12.70 without the vise, and $16.00 with vise—the latter being known as the No. 9 1/2.

There is also a splendid line of Yankee bench drills considerably

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higher in price than the Goodell-Pratt. They are, however, heavier in construction and should stand up to more accurate work. They are supplied both in hand and power drive.

The beginner may be tempted into the purchase of one of the portable electric drills, often supplied with a rack on which they may be mounted to serve as a bench drill. I would strongly advise against such an arrangement. These drills are noisy, and have lots of play due to the gearing. They are fine to throw around under cars in a garage, and will do a splendid job of drilling bolt holes for attaching license plates to the flivver—but they have no place in a gun shop where precision is the order of the day. Let the garage man follow his own methods, if any.

DRILL BITS AND GAUGES: It may be O. K. to buy screwdrivers and chisels one at a time as needed, but when it comes to drills (drill bits) it pays to buy the whole set. The different sizes vary by only a few thousandths, and without a full set one is apt to find the required size missing when badly needed. Twist drills are inexpensive in the small sizes, and in addition to a complete set, there should be two or three extras in the sizes most commonly used—then if one is broken, the work is not stopped.

The Starrett No. 185 Time Saver Drill and Wire Gauge Chart is a very necessary tool to have. It will pay every gun owner to buy one of these which lists at $2.40. It is a hardened steel plate, with holes drilled in it to fit drill sizes Nos. 1 to 60 inclusive. In addition to being used as a gauge it also gives exact diameter of drill and shows drills to be used in drilling for standard taps.

A complete set of these 60 drills will cost in the neighborhood of eleven dollars, complete with a stand in which the drills are held vertically in plain view. The stand is also numbered with the size of the drill opposite each hole. I have found Cleveland regular carbon steel drills the best for all round work. The Cleveland Cle-Forge High Speed drills or their Mezzo Super-Carbon drills cannot be beaten for hard tough steel, such as high power rifle receivers. In addition to the 1 to 60 wire gauge sizes, it is advisable to have another set from 1/4 to 1/2 inch by 64ths. Then you are prepared for any job likely to come up which can be done by hand.

The next thing needed is a screw thread gauge. The one needed by the gunsmith, amateur or professional, is the Starrett No. 473, giving thread pitch from 6 to 60 per inch. It doesn't pay to guess at the pitch of a thread—some gunsmiths do this, which is the reason Lyman sights occasionally drop off. After you have ascertained the *exact* thread use a screw tap of the right size and *none other*.

A few TAPS will be needed, but it is not necessary to carry a great number on hand. Those found most generally useful are 7/32 x 32, 10 x 32, 8 x 32, 6 x 32, 4 x 36, 3 x 48, and 2 x 56. For the benefit of those who do not understand how screw taps are

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numbered, the first figure refers either to the diameter of the screw in fractions of an inch, or to its numbered size; the second figure refers to the number of threads per inch. Thus a 7/32 x 32 screw is 7/32 inch diameter, and has 32 threads per inch; an 8 x 32 is a No. 8 size machine screw, with 32 threads per inch; a 2 x 56 is a number 2 screw with 56 threads per inch. Screw sizes are not the same as wire gauge sizes—hence the value of the Starrett gauge, which in addition to showing the drill sizes, shows what screws and taps they should be used for.

Most special sights have special sized screws supplied for attaching to the gun, the threads being finer than are considered standard. Thus the Lyman 48 sight uses screws 1/8 x 48, and the gunsmith who uses a tap cutting only 40 threads per inch is botching up the job in fine shape. Someday that screw is going to loosen and come out, and Mr. Lyman gets the blame! Why didn't they use standard screws, dern their hides! No—why didn't the gunsmith use a Lyman tap, blast his measly carcass! The finer thread is designed to hold more tightly, and the correct tap could easily have been secured. *Always*, when ordering sights, enclose an extra fifty cents and tell the maker to send you the correct tap and drill. It is a mighty fine plan also to spend a few cents more for some extra screws, and an additional tap or so. Then if an accident happens, you're ready for it. Keep the special tap in a glass jar with the extra screws, plainly labeled, and there's no guess work.

Measuring tools are of prime importance in all branches of gunsmithing. We have already mentioned inside and outside and hermaphrodite calipers in connection with wood working tools; the same calipers will be useful in working metal. However, since calipers cost little, it is well to have at least two pairs of each style, as it is very often a big help to be able to leave the calipers set for some given dimension, while using another pair for general measurements.

A good MICROMETER CALIPER is essential. Mikes can be purchased for as low as four or five dollars, but there is no economy in a cheap tool of this sort. A miss is as good as a mile when taking measurements in thousandths of an inch or less. By all means select either a Brown & Sharpe or a Starrett micrometer. There is no difference in quality, some mechanics preferring one make, some the other. The shape and size will largely influence your choice. For gun work I find the Starrett No. 231 the most useful. This instrument has a measuring range of 1 inch by thousandths on the sleeve and thimble scales, with a vernier scale also on the sleeve by which you can take readings in ten-thousandths of an inch. It also has a small thumbpiece on the end, which is provided with a click, and by setting up the instrument by means of this stem, it is always set at correct and uniform tension. While many mechanics pride themselves on having a touch so sensitive

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that the click is unnecessary, the beginner will find it a very good thing—and in my opinion the work of a lot of old timers would

be improved if they would use it.

A good 1 inch micrometer should cost around ten or eleven dollars. Never borrow a micrometer, and never lend one. Have your own, or do without. It is too delicate an instrument to be handled as some people would handle them, and unless it is absolutely accurate, it is entirely worthless.

Larger calipers measuring up to three or four inches can be had, but are not needed in gunsmithing. A two-inch mike might be handy occasionally, but these have a range of only one inch—that is, measuring from 1 inch to two inches, instead of from zero to 2 inches. Some of them have an extension anvil permitting measurements from zero to 2 inches, but are probably less accurate when the extension is used than a straight zero to 1 inch mike.

Few shops will have use for an inside mike. They are quite expensive, and cannot be used in small holes, as a rifle bore, for example. A star-gauge, or the lead slug method described elsewhere in this book, is the proper ticket for taking bore measurements. An inside mike might be useful for measuring shotgun bores and chokes, but I know of none long enough for this purpose, which requires reaching into the barrel several inches. Special long legged calipers can be used for this, the measurement from their points being read by means of an outside mike.

The Starrett No. 269 TAPER GAUGE is convenient for taking inside measurements at end of holes, and will give the bore and groove diameter of a barrel at the muzzle by simply inserting one of the blades and taking the reading at the point reached by the extreme edge of muzzle. It is graduated only by thousandths but a good pair of eyes find no difficulty in reading it pretty accurately to a quarter-thousandth. This tool lists at $5.50, with 8 leaves reading from 1/10 to 1/2 inch by thousandths.

A pair of hardened and ground V-BLOCKS WITH CLAMPS are essential in gun work, for holding round stock while drilling through the side, for holding barrels, while fitting scope blocks, lining up sights, and many other uses. The Starrett No. 278 and the Brown & Sharpe No. 750 are almost identical in size and design, and both list at $6.75 per set of two blocks and two clamps. The Starrett No. 271 drill blocks are convenient for drilling scope block screw holes in barrels also. These blocks are mounted to slide on a rod, with a clamp on one block to hold the barrel or other round stock. List price for set complete, $3.30. Unless you have an accurate drill press, the drill blocks are largely useless. If you have to drill with a hand or breast drill, line it up by eye the best you can—which is about as good a way as any after you have the holes properly located.

SCALES: Two or three high grade steel measuring scales

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should be in every shop. For most work 6-inch scales are long enough; of course there should be a long folding rule for measuring barrels, stocks, etc. One scale graduated to 64ths and another to 100ths will take care of your jobs in good shape.

SQUARES: Besides a good carpenter's iron try-square, you should have two or three small ones. The particular toolmaker uses a small "standard" square for testing others that are used on the work—and the "standard" is never used on the work itself. These small squares, hardened and ground to absolute 90 degree angles, are very expensive. The Starrett No. 20, with 2 inch blade and 1 7/8 inch beam is well worth the $3.90 it costs. For general work of lining up sights, leveling barrels in V-blocks, etc., my choice is the Starrett No. 60 with 4 inch blade and 2 5/16 inch beam, costing $1.50. Two of these squares is a good investment in any shop. The Brown & Sharpe Adjustable Square No. 554 is well worth having around also. This tool has three removable blades—one for right angles which is graduated; one gives 30 and 45 degree angles, and is not graduated; the third blade is narrow—also graduated—and is adjusted to any angle within a limited range. This blade is useful in squaring off the end of a barrel that has been cut off, and similar work.

A centering square is almost a necessity in the gun shop, and is just as necessary to the amateur as to the professional. With it one can lay out an exact center line across the end of any round stock, such as a barrel, piece of tubing, etc. It is impossible to make an accurate layout for a barrel band with sight base, without a centering square. The Starrett No. 33 combination square has two heads, interchangeable. One gives a right angle and 45 degrees according to which side is used. The other is a centering head. The blade slides to any desired position, and is held tight in the head by a knurled finger screw. In the square head is a small spirit level, so that a barrel or other work can be placed absolutely vertical in the vise if necessary. This square, with 6 inch blade, and both heads, lists at $3.90 complete.

A set of THICKNESS OR "FEELER GAUGES" reading from .004 to .025 inch will occasionally prove useful; but since the cost is $2.50, would not recommend its purchase until needed. The Starrett No. 72 and the Brown & Sharpe No. 640 are equally satisfactory.

Several small CLAMPS, both parallels and C type, should be on hand at all times for use in lining up and holding scope blocks, etc., while fitting. C clamps are also used for holding on ramps and other parts while soldering or brazing. They must be of best quality malleable iron, or they will break under the heat.

The shop should also have several PLIERS with different shaped jaws, and a number of wrenches. Get them as needed.

At least two pairs of sharp pointed, accurate DIVIDERS with

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screw adjustment, should be on hand; also a good sharp pocket scriber, with hardened point.

CENTER PUNCHES, PRICK PUNCHES AND DRIFT PUNCHES: By all means include with your shop equipment a Starrett No. 18A automatic adjustable stroke center punch. List, $2.40, and worth ten times that. Looks like any other center punch, but the handle is a little larger, and the upper end is a sliding sleeve, with a coiled spring and trip inside, adjustable for tension. Place this punch on the mark, push down on sleeve, and it trips, striking a quick sharp blow and driving the point in for a perfect impression for starting the drill. No hammer is needed, nor should one be used. The punch never jumps off the mark, and the point is hard enough to make a clean impression even on fairly hard steel.

You will also need several common center punches from 1/8 to 3/8 inch in size. Be sure they are HARD. Nothing is more disgusting than a soft punch that turns or flattens its point on the work. Buy the highest priced punch you can find, and hope for the best. If they prove soft, try to harden the points. If common tempering methods do not get results, harden them in cyanide. Keep the points ground very sharp at all times.

Three or four small prick punches should also be on hand. These cost but fifteen or twenty cents each, and even the best standard makes may prove soft. Harden them also, and keep them ground sharp—some with slender points, some with points more blunt. You will need all kinds now and then.

For forty cents you can get a set of three small drift punches—1/16, 3/32, and 1/8 inch. Keep these in your apron pocket at all times—they will probably be lost anywhere else. Other sizes, both larger and smaller, from 1/32 or less, up to 1/4 inch. If you can't buy the sizes needed, get the nearest size and have a machinist turn them down on the lathe with a file. They should be annealed first, then re-hardened. Drift punches need not be as hard as center and prick punches, or they will break. Draw the temper at blue color, in oil.

A splendid drift for very small sight pins is an old de-capping punch. The point is a small piece of drill rod set into a larger piece of steel with a setscrew. Points of various sizes may be cut and set in the tool as required. The point should not be longer than necessary, to avoid bending,—1/4 inch is usually long enough.

Secure a number of ten cent nail sets of different sizes. These have the points cupped, and are excellent drifts for finished pins the ends of which show on the gun. Anneal them, chuck them in a lathe, and turn the point straight for a length of about one inch. Polish out the cupped end with crocus cloth, and there will be little if any marring on ends of drift pins. The punch should fit the pin exactly, so have them made as needed, to the sizes required.

Finally, keep a small pin vise such as the Starrett No. 162A, and special sizes of drill rod up to .040 inch diameter can be cut and placed in the chuck as needed, making a small universal drift punch of it.

A good accurate hardened steel BENCH BLOCK, while not a necessity, is a mighty convenient little tool. It provides a conveni-

ent rest for parts while punching out pins, while drilling, and for many other hand operations. It also makes a splendid block for riveting. The Starrett No. 129 block is hardened and ground, lapped and polished; it has a groove across the top, and holes of various sizes through which pins may be punched without damage, or through which the drill may pass at the end of a cut. Lists at $2.00.

REAMERS: Under this head come straight and tapered reamers, rose countersinks, taper pin reamers, spiral reamers, both straight and tapered, expanding reamers, countersinks and counterbores, and sight aperture reamers—and possibly others. You never know until you get into the job what reamer will be required—and the one you need is usually the one you do not have at hand. Buy them only as needed, at least the larger ones. They quickly run into money.

Sooner or later you will need taper-pin reamers from 3/0 to 5 in size. The Cleveland standard reamers are excellent, but high in price, listing from $1.50 to $2.00 each in above sizes. I once found a lot of these in the five and ten cent store for a dime each, and by using the mike in picking them out, got a good set in standard sizes for a song. The floor walker gave me several dirty looks, and I had traffic blocked at the hardware counter, but I got away with my reamers before he called the cops. A small tap wrench with four jaw chuck will be needed to hold the reamers; also for holding small taps.

A rose countersink will come handy for lightly roughing out a muzzle before lapping to crown—and that's about all you will use it for. A better tool for this purpose is the Cleveland bit stock countersink No. 115C, size 5/8 inch, 82 degree point, list 75 cents.

Straight reamers, and reamers with very slight taper will often be wanted for sizing barrel bands, sight base bands, etc. Barrel tapers vary and it will usually be found that many of the tapered reamers have too much taper; while straight reamers do not give any taper. Hence, few if any tapered reamers will be suitable for this work, the best plan being to ream the hole in block or tubing straight, then shape the band roughly and peen it to size and taper on the barrel—or, better, on an old barrel having the same size and taper. For this work a few Critchley expanding reamers will set you right up in business. I use the 6 blade reamers which have less tendency to chatter than those having 5 blades. These blades have adjustment by means of a tapered bearing surface on the shank,

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on which the blades rest, being held at each end by a screw collar. Screwing the collars back on the shank sets the blades on a higher point on their bearing surfaces, enlarging the cut. The reamers have no taper except for a short distance at the point, for relief in starting into the hole. The following table gives catalog numbers, sizes, and list prices on those likely to be needed:

Catalog No.	Expansion, Inches	Price of Reamer	Useful for:—
19	27/64 to 29/64	$4.50	Slight ramps and small swivel bands.
20	7/16 to 1/2	4.50	
21	1/2 to 9/16	4.50	
22	9/16 to 5/8	4.50	
23	5/8 to 11/16	4.75	Medium bands and larger ramps; slight base bands.
24	11/16 to 3/4	4.75	
25	3/4 to 13/16	5.00	
26	13/16 to 7/8	5.00	Slight base or large swivel bands.
27	7/8 to 1	5.50	Slight base bands, Krag or 8mm.
28	1 to 1-1/8	5.50	Slight base bands, Springfield.

WOW! Yep, it costs money for a gunsmith to tool up—and how some folks do kick when he charges them a little profit on the job, trying to get back some of his investment.

Counterbores for flat head and filister head screws will be needed occasionally, as, for example, when changing the position of a tang screw in a rifle, or when putting on a welded false tang. These have round shanks, for use in breast drill or drill press. A counterbore is really a small end mill with a pilot to fit the screw hole. In ninety-nine cases out of a hundred—and maybe more than that—it will be found there is no standard counterbore bit to fit the particular screw. In that case you must discard the bastard screw originally used, or else turn the head down to size to fit the counterbore—or else make a flat drill with a pilot, as described in the next chapter, which will usually stand up all right on one or two jobs. Considering their small size, counterbores are expensive—better buy them only as needed.

DIES AND DIE HOLDER: Usually the gunsmith will be able to use standard machine screws to a great extent, or else screws obtainable from the factories. When a screw has to be made it is a lathe job, and the thread can be cut more accurately on the lathe than in a thread die. It is doubtful, therefore, if a set of dies will pay dividends even in the professional's shop. If you decide to buy a set for use at home, consult your hardware dealer, and select from his wholesale catalogs those sizes that you are going to require.

CHISELS: Depending on the work you go in for, you may sooner or later require cold chisels, cape chisels, and "diamond point" chisels. Start out with a good ¼ inch cold chisel, and another ½ inch; add other sizes when and if needed. Cape chisels and diamond points may prove handy for roughing off stock where there is considerable to cut away; and this also applies to round nose chisels. Sizes from ⅛ to ⅜ inch in the various styles will

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probably covered all requirements. The Hargrave line of chisels for iron and steel is hard to beat, and most good dealers have them or can get them from jobbers. Most gunsmiths keep a few pieces of hexagon tool steel and make chisels of the size and shape wanted.

HACKSAW FRAME AND BLADES: Get a "pistol grip" hacksaw by all means—for what sawing you do will often be done to take the place of some milling or planer operation, which means lots of sawing. A Diston, Atkins, Starrett or other standard make costs but little more than some "off" brand, and is stronger and more rigid. You will want fine tooth blades for thin stock and thin tubing, and coarser ones for heavier work, roughing off stock, etc. After using all kinds of blades, I have concluded there is but one kind for me—the Universal all hard Tungsten Steel blades. The 12 inch length is most convenient. A shorter blade than this is a nuisance, while a longer one is a little too springy for fast work. Use 18 teeth to the inch for roughing cuts and heavy stock; 24 teeth for smoother, more accurate cuts and lighter jobs; and 32 teeth for thin tubing.

HAMMERS: It pays to get good ones, even though you do not use them a great deal in gun work. My own choice is a Maydole ball peen machinist's hammer of 36 ounces; another of 24 ounces; and another of 3 ounces; also a Maydole 6 ounce riveting hammer. The manufacturer's numbers on these are, respectively, 121, 123, 129, and 265. Also, a Goodell-Pratt brass hammer, No. 93, weighing 8 ounces, and a solid copper hammer of 1½ pounds weight. Lead hammers can be cast as needed using a hollow wood cylinder for a mould, with a hole in one side through which a plug is inserted to form the hole for handle. A rawhide mallet is nice but I have a plain wooden one which I seldom or never find use for.

Some means of heating a SOLDERING IRON will be necessary, also the iron, or "copper" as it is more correctly called. Buy the best soldering copper you can find, weighing from 1½ to 2 pounds. A small one from the five and ten cent store will come in handy also for tinning the inside of ramps and bands, or one can be made from a piece of round copper rod. A good blowtorch will cost from $3.50 to seven or eight or ten dollars, and it seems like one is just about as good as another. The Turner and the Clayton and Lambert torches have the reputation.

BENCH KNIFE: A good strong sharp blade is indispensable and in this day of helpless critters who can't appreciate a pocket knife with hardened steel in it, the best we can get in pocket knives are so soft that the edge will not stand up even to ordinary work. The Swedish steel bench knives sold by Hammacher, Schlemmer & Company, New York, cost only 35 or 40 cents, and beat any pocket knife costing two or three times their price. It pays to have two of these knives, keeping one very keen and the other for rougher work, scraping, etc.

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SHARPENING STONES: Several of these will be needed. The first should be a Carborundum combination stone, 8 x 2 x 1 inch in size, coarse on one side, smooth on the other. This will be used for dressing edges and first whetting of chisels, plane bits, etc. Specify stone No. 108. Next, a Lily White Washita, about 6 x 2 x 1 inch for final whetting of wood cutting tools. Then a No. 186 Carborundum slip stone, 4 inches long and 1 inch wide, with edges rounded, 7/16 and 3/16 inch thick respectively, for inside of carving chisels; this is used only for the first whetting. Use a similar stone of Lily White Washita for finishing.

Carborundum and aloxite sticks may be had in square, triangular, half round and round cross section, and in fine, medium and coarse

grits, at prices from 60 cents to $1.50 each. They are useful for dressing up and reshaping hardened parts that cannot be filed, and should be bought as needed. Pike India Oil Stones can be had in many odd sizes and shapes, and should be bought as required, the purchaser selecting them from illustrations in any large tool house catalog. The No. 27 stone, known as a "point" is round in section, 3 inches long, 5/16 inch diameter, and tapering to a very sharp point. It is indispensable for getting into small corners and grooves, when a file will not cut. The No. 58 is larger, being 4 inches long, ½ inch diameter at one end and ¼ inch at the other. A very useful stone in reshaping parts of sears, triggers, etc., when the file will not cut. Last but not least, the stones for easing trigger-pulls. There are two kinds of Arkansas stone, known as "Hard Arkansas" and "Soft Arkansas." Specify the hard and refuse the soft. Slip stones for trigger work should be about two inches long, 3/16 inch thick at one edge and tapering to a knife edge on opposite side. This material is also available in round, square and triangular "sticks" the last two shapes being most useful. Buy them only as the need arises.

I hesitate to bring this chapter to a close. Already it has taken more than its rightful share of space, and has named so many tools, etc., that the reader may have gained the impression that even a small tinkering shop is beyond his financial statement. Time after time I have checked over my own tool equipment, in an effort to miss nothing essential, nor to include nothing that might not be definitely useful or necessary. My own work has covered a wider field, perhaps, than the average amateur will cover in a few years of tinkering his guns; and he should therefore discard at once the idea that it is necessary for him to have everything mentioned or to be mentioned later before he can restock his pet rifle or put on a new sight. Far from it! Start with the fewest possible number of tools—you'll be surprised how rapidly they will accumulate, as your hobby grows and develops.

Chapter 4

SPECIAL AND HOME-MADE TOOLS AND EQUIPMENT

HAVING rigged up a place to work, and assembled a few of the most essential tools, the amateur gunsmith will next consider certain other equipment, some of which is necessary to certain jobs, while other items may be dispensed with, but will nevertheless add both to the pleasure, speed and convenience of the work. For the gunsmithing trade calls at times for tools not regularly listed or manufactured, and which if ordered specially from a tool maker, would cost a great deal. Fortunately, most of them can be easily made by the amateur.

Before going into details of these special tools, let's consider a few of the non-essential but worth while ones.

The first is a high grade MOTOR GRINDER. When I first started tinkering with guns I had no grinder—and now I wouldn't know how to get along without one. Many long hours of filing have been reduced to a pleasant few minutes work; to say nothing of the advantage of being able to buff and polish parts quickly and more perfectly than by hand.

There are three well known makes of grinders of the type I am going to recommend—the Black & Decker, the U. S. Electric Company, and the Van Dorn. Possibly there are others I have not seen. Of the three named, I believe one to be about as good as another. The first two are somewhat heavier, and might stand up better under long hard usage. They cost about $60 and $50 respectively, while the Van Dorn, a trifle lighter machine, costs about $40. All three are ball bearing, with an automatic built-in starting rheostat, rubber covered connection cable, and socket plug, operating on any ordinary lighting circuit. The grinder is small and compact, and sets conveniently on the bench, or may be had with a cast iron floor pedestal at an additional cost. The shaft is 1/2 inch diameter, and has a

6 inch Alundite wheel 1/2 inch thick on each end—one coarse, and one fine. Other wheels of various sizes, shapes and thicknesses not exceeding these dimensions may be added as needed. The wheels have removable guards and tool rests adjustable for height and cutting angle. With the wheels removed, you can use wire or cloth buffers, wood wheels faced with abrasive cloth, sandpaper wheels for dressing down butt pads—new uses will be continually occurring to the owner of one of these splendid machines. By using Alundite wheels with thin, rounded or beveled edge you can get into places in shaping up parts that would ordinarily call for a milling machine or shaper. Hours of filing can be saved when making barrel bands, sight bases, ramps, and similar jobs. Tools can be sharpened—although these wheels are too hard and fast (3000 to 3600 R.P.M.) for carving chisels and plane bits which are best ground on an old fashioned grindstone.

Soft steel wire buffers are splendid for carding off the rust during the bluing process, and, with light pressure, for burnishing a barrel after it is blued. A separate wire buffer should be kept for carding off rust, and this must be boiled in lye or sal soda to remove all grease, then rinsed in clean boiling water. If the bristles should rust a bit, that is the best evidence that there is no grease or oil on them to spoil the bluing job.

You will want two or three cloth buffing wheels 4 inches in diameter, and two or three 6 inch ones. These are not much good until worn down to an even surface on the edge. Start the motor and hold a sharp chisel against the cloth until all loose edges, threads, etc., are worn off and the surface is smooth and compact.

Keep one cloth wheel clean and dry, for final polishing; keep another for use with Tripoli rouge; another, perhaps, for fine jeweler's rouge. Others may be surfaced with a little fine emery or carborundum in heavy grease for preliminary polishing of parts.

Wood wheels can be made as needed. Scribe a circle the required size with dividers on a piece of clear soft pine; bore a half inch hole through the center for the shaft, and saw and file the wheel to shape on the outline. Set it on the shaft, tighten up the nut to hold it, then start the motor and turn the wheel true by holding a slightly curved very sharp chisel against it, then finish with sandpaper.

Coat the edges of these wheels lightly with glue or very thick shellac, then roll them in fine emery, carborundum, pumice, etc., as needed. On some, glue thick felt weather-stripping to the edge, letting the ends of felt meet evenly. The felt may be used dry for final polishing, or may be coated, either dry or with heavy grease, with various abrasives.

Make, or have made, some hardwood (preferably maple) spindles which will screw onto the end of motor shaft instead of the nut, and projecting from two to four inches beyond the end of shaft. The projecting ends may be shaped as desired, to reach through trigger

guards and other places for inside polishing. Coat them with glue and wrap on felt to hold the abrasives.

Special wheels of compressed felt are fine for polishing, but very expensive. If you can afford a few of them they will make a hard job easy. They are used both dry, and with abrasive pastes.

Very fine polishing wheels are made by cementing together several thicknesses of heavy leather—sole leather or saddle skirting. Bore the shaft hole and saw them round with a coping or scroll saw, then turn them true on the shaft with a chisel. Edges may be made square, round, V-shaped or beveled as needed. Rub valve grinding compound on some and keep others for use dry in final polishing.

You can get a drill grinding attachment for use with your grinder for about $12.00. Many mechanics scoff at these attachments, considering themselves competent to hold the drill in their fingers and grind it true. Grinding a drill is about the most particular job you will find, and one of the hardest to learn. The attachment will soon pay for itself in drills saved or reclaimed—for be it known that a dull drill, or one ground off center is useless. Off center grinding of the point causes a drill to cut a hole larger than itself—a serious matter when a certain screw is to be tapped into the hole. Accurate grinding of very small drills is almost impossible without the attachment.

Another useful accessory is a chuck, made to either screw on end of motor shaft instead of the nut, or else to be slipped on and held by a set-screw. Drills may be held in the chuck for boring; small pieces of drill rod may be turned to size for pins by holding a file against the rod while motor is running; often a new firing pin can be turned out with only this chuck and a file for a tool. Round parts may be chucked for cutting down slightly, or for polishing. Finally, a pully may be placed on one end of the motor shaft, and belted to a bench drill, small bench lathe, drill press, or to another grinder, in case you want one slower running than the motor itself.

The best substitute for a small motor grinder, is a GRINDING HEAD which can be purchased from the mail order houses for four to ten dollars. This can be belted up to a 1/4 h.p. motor, a fan motor, gas engine, or even the old flivver. The lad on the farm, where electricity is not available, will connect up his grinder to the tractor, milking machine, log saw or washing machine. Leave it to him—he'll get power to it. A grinding head, belted for a speed of 1500 to 2500 R.P.M. is better for some work than the high speed grinder—but the latter is supreme when roughing off a lot of surplus metal in making parts from rough stock.

The amateur gunsmith should manage if possible to have some kind of a motor, even if nothing better than a fan motor is available. Small cloth and steel wire buffers are almost indispensable at times, any investment you make in this direction will quickly pay for itself.

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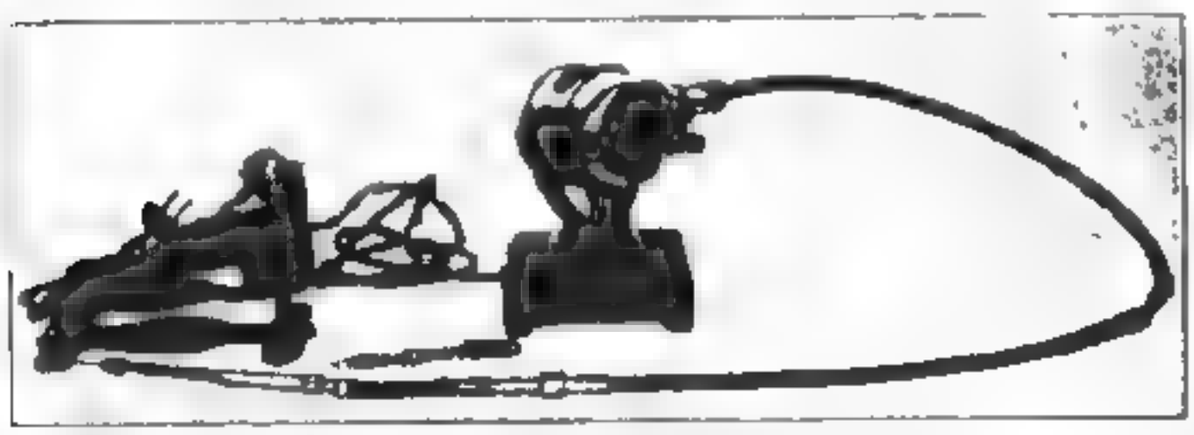
THE DENTAL ENGINE. Now for another suggestion, for which I am deeply indebted to the dental fraternity. This will not be new to some people, but will be to many. When you sit in the dentist's chair inwardly cursing the fiend as he drills into the old molars with such keen delight, probably you paid little attention to the makeup of the principal tools he was using. Yet if you had that "dental engine" of his in your shop, you would find a million and one uses for it on every job, big and little.

Dentistry and gunsmithing are two widely separated professions but the professional gunsmith will do well to investigate this piece of dental apparatus and learn of its daily application to his business.

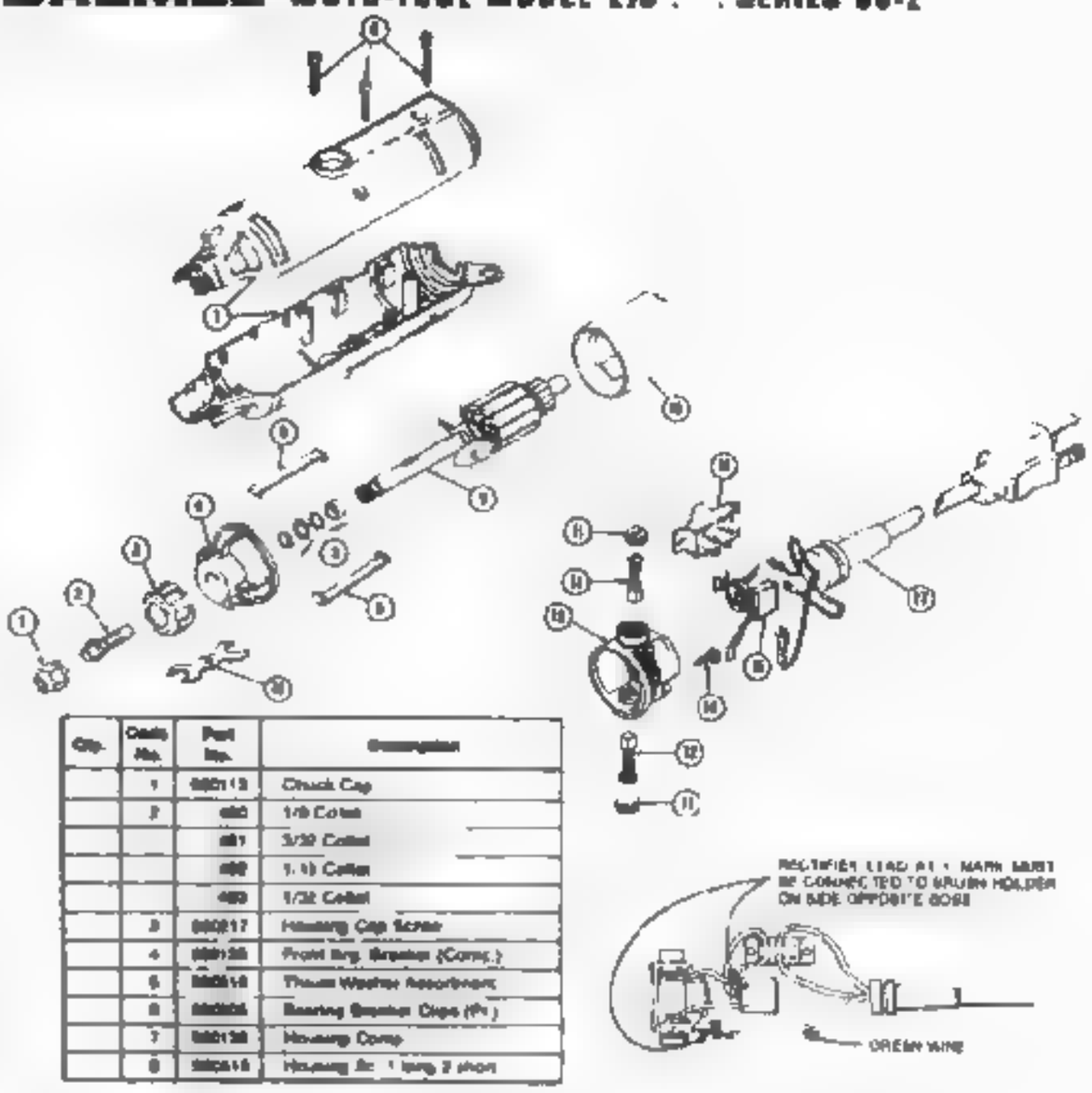
The old time dentist used a villainous arrangement on a tall stand, with wheels and string belts, operated by a treadle which he worked with his foot. From this ran a flexible or jointed shaft to the drill head with which he did the dirty work. The modern dental engine



THE DENTAL ENGINE

consists of a small and compact motor all nickled and shiny, and with about six feet of rubber covered flexible shaft; the business end of the shaft is attached to a nickeled tool about ten inches long which serves as a handle. In the end of this is a small chuck in which Doc holds his burrs, drills, carborundum wheels, and other implements of torture designed for proselyting Christian Scientists from the true faith. The chuck is arranged so that the burrs and wheels may be mounted at right angles to the handle if desired. Now this chuck is removable, and in its place may be inserted another chuck with a head which converts the rotary motion to a hammer motion—in other words, converts the gadget into a miniature riveting machine. After this brief explanation, consider the following suggestion: Next time you call on your dentist, control your feelings and temper if you can; but if he tortures you beyond human endurance, then slay him with the jaw-bone of an ass or whatever is handy—and don't leave the place empty handed. Steal his dental engine and as many of his tools as you can stuff in your pockets. Also loot the body of any spare change you may find.

(Rather than bothering about a dentist's drill, go to any hobby shop, a well-stocked hardware store, Sears etc. and buy a Dremel Moto-tool or its equivalent. All or most of the burrs, wheels, etc., are stocked).



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If you hesitate to pursue such a course, then your best bet is to make your peace with your local tooth puller and tell him your troubles. If he happens to be a gun-crank,—and a lot of them are, for some reason—he'll understand at once. If he hasn't an old obsolete engine that you can talk him out of for a song, he will be glad to help you select the type you need, and will probably order it for you from his supply house. And his experience with the various tools and attachments will enable him to offer many helpful suggestions—moreover, he will likely make you a present of a double handful of old burrs, too worn for use on teeth, but fine for metal. And you

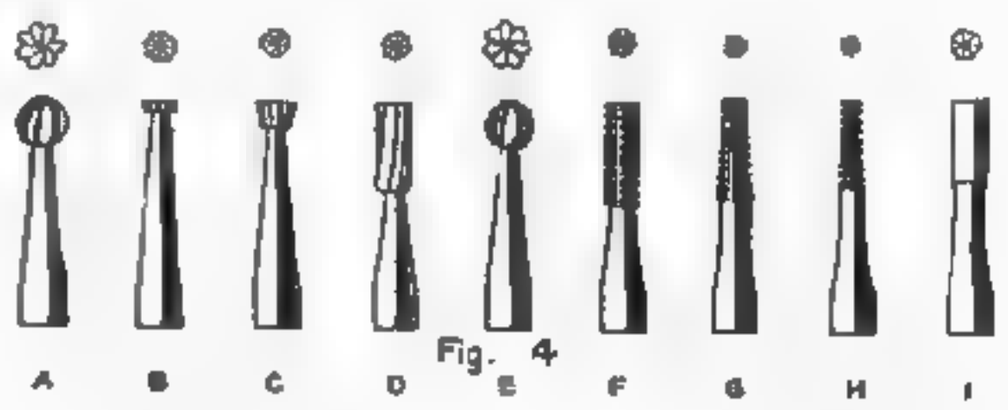

Fig. 4

can buy others as you need them, for the cost, barring the cost of a new dental engine, is surprisingly low. As this is written I am advised that the S. S. White Dental Mfg. Co. are putting on the market an engine to sell at $25.00—lacking the motor. The shaft is made to attach to any small motor, with suitable connections.

Figure 4 shows a number of dental burrs (they are always called "burrs" and not "drills") useful to the gunsmith. These come in sizes from No. 1/2 to No. 11, ranging from about .023 inch diameter. The No. 6 measures .067. This is a handy size for countersinking rear sight apertures, or for straight drilling where a very small hole is wanted—the pin hole in a front sight blade, for example. A number 3 or 4 round burr makes a splendid center punch. Figure 5

It will not slip and slide off the mark even on hard surfaces. The hole may be started with a small burr, and enlarged to exactly fit the drill to be used later. Spot annealing is unnecessary, for these burrs are made to cut the hardest material.

Another advantage of using burrs is that they will cut on the side as readily as the point, hence need not be held perpendicularly. Hold them at an angle as you hold a pen in writing— the tool never hides the work and you always see what you are doing.

The Wheel burr, Figure 6, is really a small milling cutter—excellent for getting into difficult corners and uneven spots. Uses numbers 11 1/2 to 22.

The Inverted Cone, Figure 7, is used as a straight drill for small holes—cuts very fast in all sizes. Use numbers 33 1/2 to 44—they

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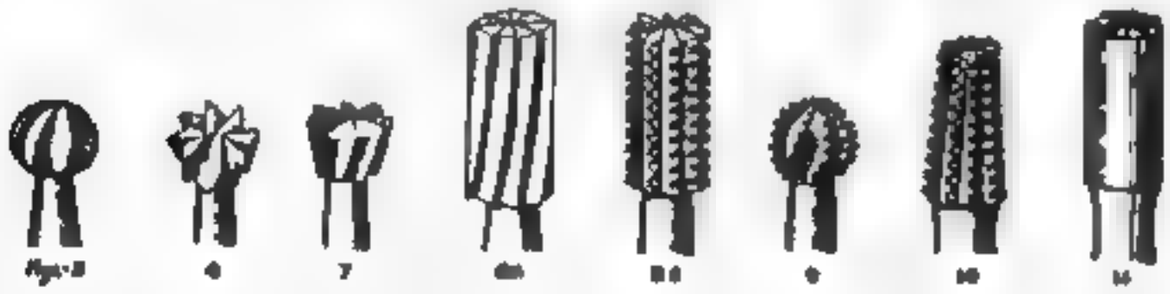
make excellent milling cutters in all sizes, even an old discarded one cutting through case hardening easily.

The Fissure burr, Figure 8, is one of the handiest of the lot. "A" is a plain burr, while "B" is a cross-cut Fissure. The sizes most commonly needed will be Nos. 557 to 562. Use it, for example, instead of a "mouse-tail" file for cutting the half round groove in a Springfield barrel through which the fixed stud pin is inserted. Cutting



on the end as well as on the side, this type of burr is especially valuable in small "tight" jobs.

Figure 9, shows a cross-cut Cherry. This is similar to the round burr in Figure 4, but cuts faster.

Figure 10, shows a tapered fissure burr known as an "inlay fissure"—not particularly useful to the gunsmith, but might be used occasionally.

Figure 11, is an end cutting fissure, used for bottoming out a hole or slot without cutting the sides. Better than an end mill or any other machine tool for cutting square bottom holes in barrels for scope block screws.

Twist drills, reamers and extra large diamond point drills may be had for the handpiece of the dental engine, from dental supply houses: but the discarded drills of the dental practitioner's office will keep the amateur or professional gunsmith supplied for years and save him many hours of time.

Vulcanite burrs (similar to those already described, but made for drilling and cutting vulcanite) are very handy for use on wood; also large size surgical burrs. What a convenience for some small, nearly inaccessible cut when inletting a stock, or fitting a small inlay!

Besides the burrs, there are the mandrels and mounted carborundum stones and wheels—all extremely useful. The various carborundum mounted points and wheels are shown in Figure 12. No need to mention their uses in gunsmithing—you've wished for just such a thing many and many a time! Knock off the case-hardening where you wish to drill a hole—level off projecting ends of screws in a receiver after fitting a Noske scope mount or a Lyman 48 sight, trim and smooth out angles and corners in parts that have been welded—there's no end to what you can do with these points and wheels; new uses will be found on every job.

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Fig. 13 B

Fig. 13

The Maxfield Mandrel, Figure 13, is a quick acting holder for paper discs of assorted thickness and sizes which are covered on one side of the stiff paper with sandpaper, garnet, carborundum and cuttlefish in all different size grits. These can be used for polishing out corners, small screw heads, sights and other small parts before bluing; also for removing rust and pits and uneven places, doing a wonderfully quick and thorough job. By cutting the paper disc as shown at "b," Figure 13, it can be forced into a hole for rounding and polishing the edges. The natural spring of the paper and the centrifugal force keeps the paper in tight contact with walls and edges, and rust, pits or dirt is removed in an instant, or a mirror like surface can be put on with fine carborundum or cuttlefish discs.

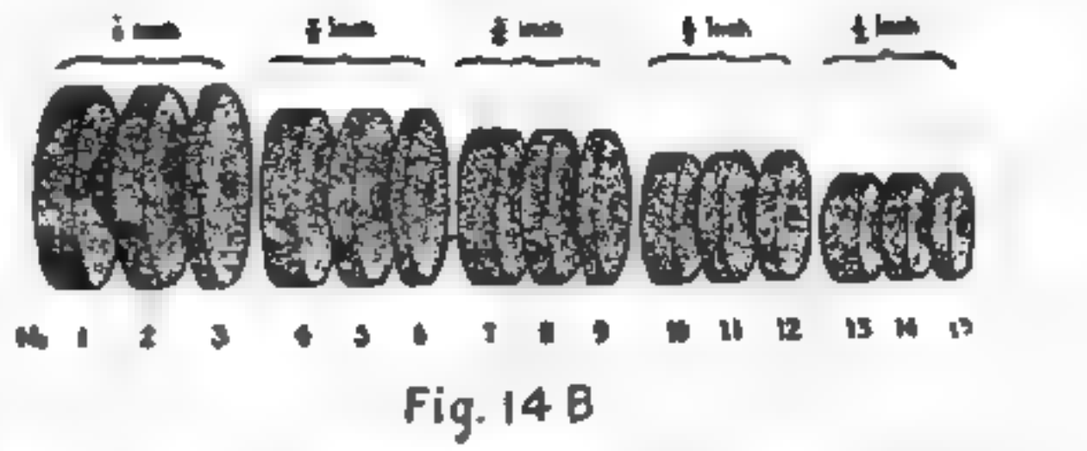

Fig. 14 B

Fig. 14

Figure 14 is a mandrel for circular stones and hard rubber discs. There are solid carborundum and hard Arkansas stones of all sizes, thicknesses and grits. These small wheels are fine for sharpening cutting and boring tools of all kinds, doing more accurate work than can be done by any other means. Sharpening hand reamers, for example is a job only for the expert grinder with a lot of special

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equipment; but the amateur gunsmith can use these wheels to sharpen his reamers several times before a trip to the grinding shop is necessary. Being under full hand control at all times they can be used right up to the cutting edge.

This mandrel also holds both circular and cup shaped stiff brushes which used with a little pumice or other fine abrasive will quickly polish any odd shaped piece, getting into corners and grooves not reached otherwise.

These are but a few of the many uses to which the gunsmith can

Fig. 12

put dental instruments. How often have you wondered about the shape and finish of the locking lug shoulders in a rifle receiver?—a magnifying mouth mirror costing about a dollar would have showed it to you instantly, as well as many other undercuts and "out of sight" places! A pair of cotton pliers (what the proletariat call "tweezers") is invaluable for picking up small screws, pins, and springs. A head mirror with a hole in the center will enable you to look into portions of a gun's internal economy you never expected to see—you can look down the barrel from the muzzle with the breech closed if you wish. Get the light in front of you, reflecting it down the barrel with the mirror as you peek through the hole. Drill a hole in any small mirror and try this.

A small carborundum stone or a cherry burr will forever elimi-

nate spot annealing—you're ready for the drill in about thirty seconds. Figure 15 illustrates cutting a screwdriver slot in a broken off screw—takes only a minute to do and the screw is then turned out "easy as pie." Figure 16 shows a .22 calibre barrel being crowned with bud-shaped carborundum and Arkansas mounted points.

The hammer motion of the special head before mentioned is useful in a variety of ways—for light riveting of pins, peening screws used

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to fill up holes in barrels, etc., and a thousand and one others. One of its most important uses is that of producing a beautifully matted surface on sight ramp, top of barrel, or even on receiver. This is described in a later chapter.

It would be possible to go on almost indefinitely naming the uses of dental instruments in gunsmithing—but one must stop sometime. For a good while I used the dental engine principally for matting,

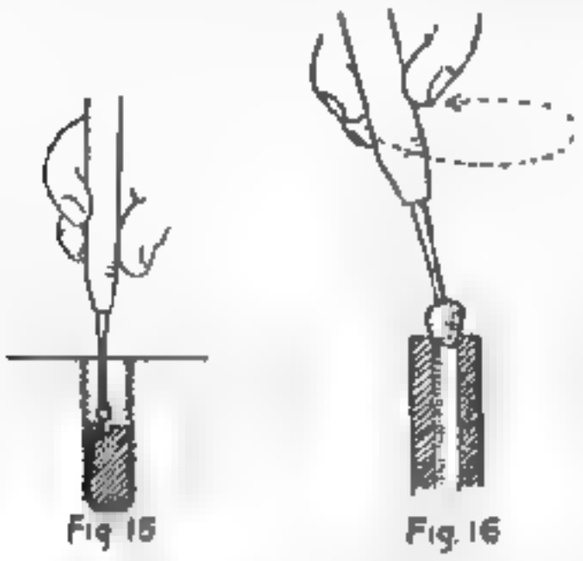

Fig 15

Fig. 16

Fig. 17

and for drilling small holes, and I am indebted to Dr. E. W. Harper, of Watertown, S. D., for introducing me to its greater possibilities. Dentistry is one of the highest branches of scientific mechanics, and the man at the bench may, by using his head, learn much from the man in the laboratory.

SPECIAL HOME MADE TOOLS: The gunsmith, requiring a tool not regularly made and sold, usually makes what he needs for the job at hand. There are, moreover, numerous tools used almost constantly that he will have to make or do without. Among these may be mentioned split screwdrivers. Make these as shown in Figure 17. Eight inches is a convenient length, and handles are not necessary, neither need they be hardened and tempered, as they are used only for holding the screw while starting it into a hole that cannot be reached by the fingers. Make them up in several sizes to fit most screws used in guns, selecting drill rod of the nearest size for each one. Make the split about 1 1/4 inches long with a hacksaw blade having the "set" ground off the sides of teeth. Shape point as shown with the rattail file. Half a dozen split screwdrivers in a box that is easily accessible are a real convenience.

CHECKING TOOLS: The amateur gunsmith will require at least two tools, while the professional will want half a dozen or more in various sizes and cuts. So many different patterns have been described in outdoor magazines in recent years that one is puzzled as to which type to select and learn to use. For be it known that none of them will do even passing good work for the rank, raw be-

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ginner. Checking is an art, just like sculpture, or rolling Bull Durham, or running over pedestrians. It has to be learned. Given the finest checking tools ever made the amateur will find them as awkward as his first pair of skates, and will swear to high heaven the tools are worthless.

And right here I want to digress for a moment. This thing of blaming one's lack of skill on the tools is why a lot of folks never learn to shoot. There never was a gun turned out by any reliable factory that wouldn't hit somewhere in the neighborhood of where it was held. There is a type of individual who is of a nervous temperament, and who cannot be suited. I have a friend who is a pistol and revolver fan. Neither Colt nor Smith & Wesson ever made a gun that was exactly right, for him. One time the gun will be shooting low; another time high; again ignition is poor. Always there is a perfect alibi in the gun, to account for the poor shooting. Another may take the same gun and make good scores with it—makes no difference—the damn gun is no good.

Trapshooters are also prone to blame it on the gun. Either the stock is too straight or too crooked, or it has too much pitch or not enough. They wear out their guns with continual alterations—"raising the pattern" and similar superstitions; they bankrupt themselves buying new guns, and immediately selling them at a heavy loss; yet they never learn to shoot. The man who is so constituted that he will break right down and admit that maybe the man who built the gun knew just a little something about gunmaking, is very likely to take most any gun out and bust his share of bluerocks, or bag his share of furred or feathered game. Practice is essential to good shooting. The man who practices constantly with a poor gun, or an ill-fitting gun will be a far better shot than the one who tries out and discards a dozen or so a year, though the latter may burn more powder. The fact is a man has to handle and shoot a gun a good while before he can really say whether it fits or not—and about ninety-nine per cent. of the birds who bellyache about their guns don't use them long enough to get acquainted with their good or bad points.

So it is with checking tools, or any other tools requiring reasonable skill to use. The amount of time you spend learning to use them makes a lot more difference than the type of tools you have. Chapter 12 of this book is intended as a complete course in the essentials of checking; and if you will follow the instructions given therein you may later design any kind of tool you please, and you'll be able to use it. What you know about checking is what counts most.

The tools I shall describe were introduced to my attention by John Dubeil who used to make stocks in the Hoffman plant—and a better stockmaker, or a more painstaking workman than John, I never expect to find. These tools have given the best results of any in my hands. Maybe they won't in yours. But as I have tried about every kind I have ever heard of, my best advice is that you make up this

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type of tool and LEARN TO USE IT—then, if you find better tools, there's nothing on earth to stop you from changing. Your skill won't leave you on that account.

Figure 18, shows three tools and a bent escapement file. "A" is the line spacer; "B" is the V-tool or deepening tool with which the diamonds are pointed up; "C" is a border cutter—seldom necessary but sometimes used; and "D" is the file for finishing up the diamonds.

All these tools but the file may be made of 5/32 inch drill rod. The V-tool may be made of 3/16 inch rod if preferred.

Cut a piece of rod about 8 inches long, heat the end cherry red and forge it flat, then bend to the angle shown. Shape it up carefully

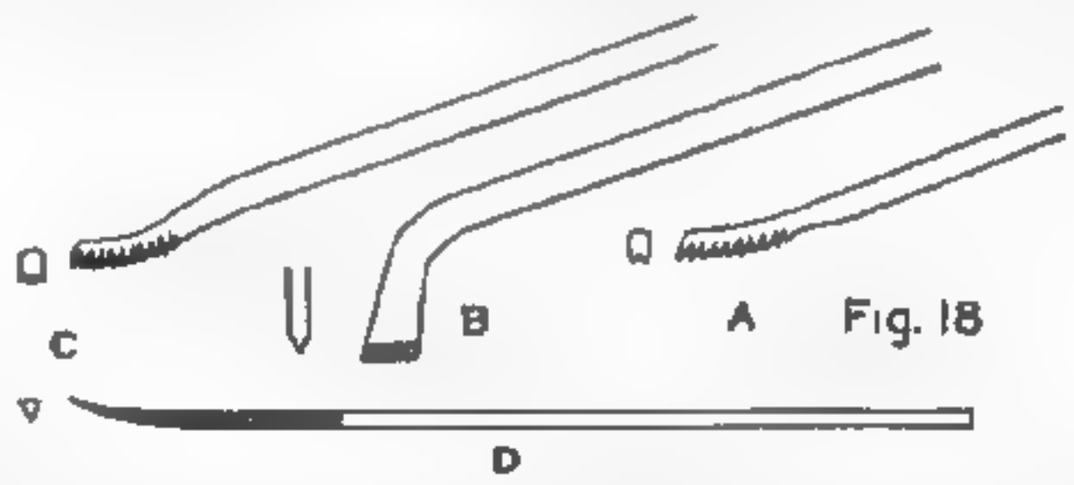

Fig. 18

with a file; cut the groove in underside very deep, using a die-sinker's knife edge needle file. Use a 3-square escapement file to cut the teeth, and note that these are cut on the sides of the tool, and not across the bottom. Each of the two edges of the line spacer is sharp, so that the file, being turned in slightly during the cutting, the teeth take form both on sides and bottom edge. The teeth may be almost vertical, or they may lean forward or back slightly. I have all three kinds, as some work better on some woods and some on others. Generally I find that the tooth which slopes back toward lower edge follows a line easier, and cuts with less tendency to catch and jump. After cutting the teeth on both sides, heat the cutter end bright cherry red and dip it in water; then dip in linseed oil and flash off the oil once to draw the temper. This leaves it plenty hard for good work, yet soft enough so that the teeth may be touched up a bit with a file when dull.

Before cutting the teeth rub the two edges of cutter on a block of wood and measure the distance between lines carefully with sharp dividers. Then after the teeth are filed, cut a few lines and see how many they run to the inch. If the cutter is too wide, dress off both sides slightly until the cut is narrowed sufficiently and re-sharpen

the teeth before tempering. The size cuts best adapted for various grades of wood is discussed in Chapter 12.

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The size of the teeth of a cutter may vary from 16 to 24 per inch. Hard wood without large open pores is easier to check, and a 20 or 22 point cutting edge is very satisfactory. 16 to 18 points seems to work best on more open grain wood. There is no convenient way to accurately space the teeth—file a few on scrap stock for practice and measure them, then space them by eye, preferably under a jeweler's magnifying glass.

I've heard a lot about three and four row spacers, and while the idea sounds splendid, I have yet to see any such that would work, for me. Of course in such a spacer the teeth must be cut crossways, while the side teeth can be cut only on the two row tool. And the side teeth are the ones I will continue to use until someone shows me the error of my ways.

The V-tool is forged out to the shape shown, and filed to about 1/8 inch thick or less, then the edge beveled back about 1/4 inch, forming a sharp V. This edge should have an angle of about 26 degrees, or a trifle less than the angles on a 3 square file. Cut the teeth on the sides just as you did on the liner, but make them very fine—as fine as you can cut—and space them if possible so they will be even on both sides; otherwise the edge may be ragged. After this tool is hardened and tempered, the teeth should be touched up lightly on the sides with an Arkansas slip stone, to even them. This tool seems to work better and be more easily controlled after it is broken in and dulled a trifle.

The border cutter cuts a sort of reverse bead—a thin V line, a wider U line, and another thin V line. Personally I do not admire these borders on checking and seldom use this tool.

The border tool must be toothed across the bottom, since there is no other way of forming teeth on the middle section; but these teeth should run diagonally, rather than straight across, at about the angle of the teeth on a mill file—and their shape should follow the teeth of a cross-cut saw, rather than those of a ripsaw. Teeth should also be cut on the sides, similar to the line spacer, these teeth corresponding to those cut across the bottom.

Any of the three tools above described may be made in any size desired. Square up the end of shank by filing or grinding to a point and drive on a common file handle of a size that fits your hand well. The length of tool, from ferrule to point, should be from five to six inches.

The bent file is made from an escapement file, or a 6-inch die-sinker's 3-square needle file. The escapement file is best. To bend the file without blunting the teeth you will need a small quantity of the file-hardening compound described in Chapter 21. Coat the points of the files with this mixture and let it dry slowly for a day. Then heat the point dull cherry red and quickly press it against a piece of brass. It cools very quickly and two heats will probably be needed. Let cool, and again coat with the hardening compound

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and let it dry. Then harden by heating the point bright red and dipping into cold water. The compound may then be brushed out with a file card. This leaves the file very hard and brittle, so use it carefully to prevent breaking. The compound is used merely to prevent the heat from forming "scale" on the edges of the teeth.

Figure 18-E shows an ingenious checking tool designed and made by Mr. John Crowe of St. Joseph, Missouri, while Figure 18-F shows a modification of the same tool which I made after seeing Mr. Crowe's. This tool, by reason of the single edge cutter may be shaped up very accurately. The guide is pivoted at the rear. with a small coil spring which forces the edge of guide below cutting edge normally, but permits the cutter to be pressed down onto the wood against the tension of the spring. The guide thus rides in the last cut, keeping the cutter in line and parallel with it. This one tool is used both for the preliminary spacing and for the finishing of the diamonds, and does a good job. I found Mr. Crowe's device a little awkward at first, as I am accustomed to using longer tools. This of course is only a matter of habit, and what we are used to. The longer cutter with narrower blade gave me better results; and while only time and use can show the possibilities of a checking tool, I would not be surprised if this should make a convert of me in the course of time.

SPECIAL KNIVES, SCRAPERS, ETC. Make these as needed from hacksaw blades, harden and temper in oil. Knives having

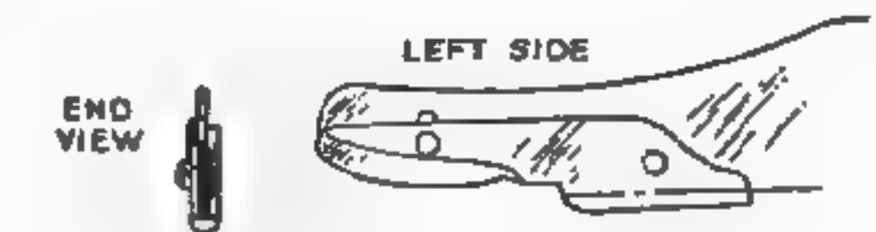

Fig. 18 E

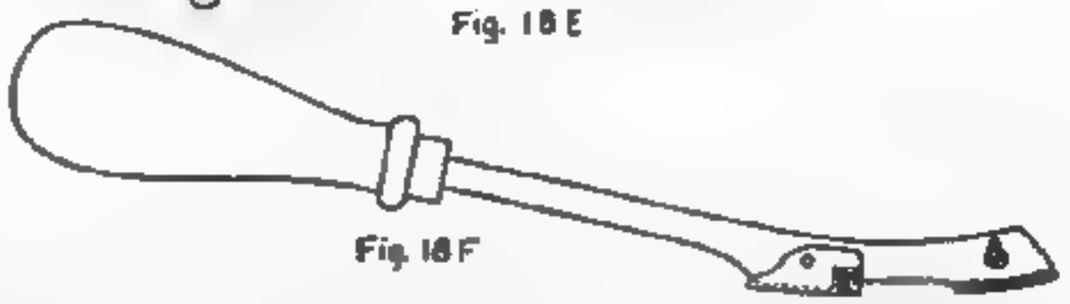

Fig. 18 F

bent blades of various sizes and shapes are very handy in trimming up difficult places in stock mortices.

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BOTTOMING TOOLS. Ordinary chisels and carving chisels often will not reach into a deep cut to clean out the bottom surface smooth and even. A bottoming tool should be made from drill rod, forged and filed to shape to meet the requirements of the job. Typical bottoming tools are shown in Figure 19. They may be any shape indicated by the cutting you want to do, and may be made of drill rod.

Fig. 19

Heat the end cherry red and quickly clamp it in the vise, then upset the end to desired size by hammering. Two heats may be necessary. Then heat and shape the shank as desired, file to shape, harden, and temper at light straw. The edges should then be sharpened on an oilstone. Square the shanks and fit file handles. Make up a bottoming tool whenever you feel ambitious—there's no such thing as having too many of them.

Special shaped chisels are sometimes made by filing a piece of drill rod to the desired contour. Very good small gouges are made in

Fig. 20

this manner. Their quality is improved if forged a little before shaping up. Temper in oil at light straw, and hone edges carefully.

SPECIAL RASPS AND RIFFLERS, for wood and metal often save time and labor. These should be made from high grade tool steel, the teeth carefully filed in after a little forging to make the grain more compact, and then hardened in oil at bright red heat. Draw the temper in a clear gas flame, but draw it just as little as possible—just enough to take the stress out of the metal and avoid breaking the teeth off. Chill in water the instant a *very pale* straw color appears. Figure 20 shows a couple of quickly made rifflers

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that are very handy for roughing off metal, and others may be made any shape to suit the job. Ten or twelve teeth per inch will be about right.

Before trying to hold a barrel or a finished stock in the vise, make a pair of VISE-BLOCKS like Figure 21. Saw these from hardwood about 7/8 inch thick, and glue heavy felt (1/2 inch thick) to their faces. The notch rides over the sliding bar of the moveable jaw, and the felt absolutely protects the finish of parts and prevents it being marred, yet the vise can be set up very tight if necessary.

Also make FALSE VISE-JAWS for holding small metal parts without marring, by bending pieces of heavy sheet brass or copper to hang on the vise-jaws. False jaws of lead or babbit are also very useful at times. These are easily made as follows: Unscrew the

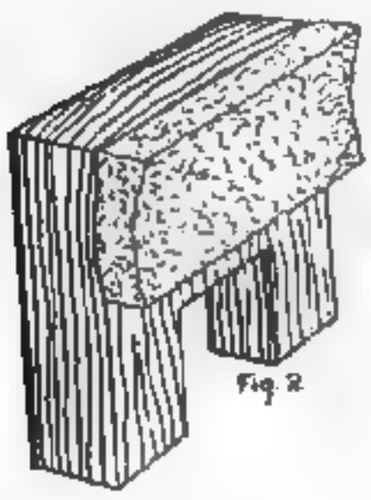

Fig. 21

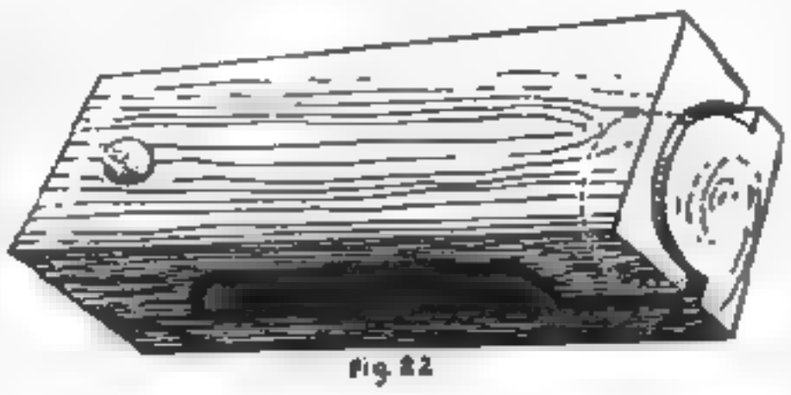

Fig. 22

vise so the jaws are about 3/8 inch apart. Get a lump of stiff clay and pack it against the opening at each end, letting it extend like a box about 1/4 inch above one jaw, and across the jaw about an inch from the edge. Also pack clay under the opening between the jaws. This forms a mould into which the lead is poured. When cool, loosen the vise slightly and lift it out; cast another one in the same way, and you have one for each vise-jaw. With these lead jaws heavy pressure may be applied to hold parts without damaging them; moreover, parts that are so shaped that the regular vise-jaws will not grip them, are easily held rigid in these lead jaws.

The average man would be stumped at the problem of holding a shotgun trigger guard, for example, without bending it in the vise. The gunsmith shapes up two pieces of wood to fit the shape of guard, and fastens the ends together, making the false vise shown in Figure 22. The guard is placed between the wood jaws which are then clamped in the vise, and the guard held firmly for filing. The same idea may be adapted to any thin parts, and is particularly useful for filing flat springs which might be damaged if straightened out in the vise.

SCREW VISES: Cutting down a small screw to very short

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length is a hard job. It cannot be held in the vise, nor in the fingers. Take a piece of brass 1/2 x 2 inches, and about 1/16 inch thick. Drill and tap a hole near one end for the screw. Turn in the screw the required distance and grind off the projecting end. The thread will be clear to the extreme point when it is turned out. For screws 1/8 inch or larger which must be filed, run a narrow saw cut from the end of the brass into the hole. Turn the screw in the required distance and clamp the brass strip into the vise edgeways, the sawcut giving a tight grip to keep the screw from turning. This kind of a "screw vise" is also handy for rounding off the end of a headless screw, for use in unused sight screw holes in barrel, tang, etc.

PITCH GAUGE: Buy a common steel square and rivet, weld or braze a four-foot strip of steel in line with the edge of long blade. By holding the short blade against buttplate of rifle, with the blade touching aperture sight at a point in line with center of aperture, the distance from blade to front sight at point on blade immediately above front sight, gives the pitch of the butt.

FLAT DRILLS for bottoming, counterboring, etc. Figure 23 shows various types of flat drills easily made for special jobs. In certain alterations in which original parts are bent or welded, the screw holes are sometimes squeezed or filed. Standard drills and countersinks probably will not serve to open up or countersink a new hole, as the screws are likely to be bastard size both in shank and head. A flat countersink or counterbore may be made from

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drill rod. Cut a piece two or three inches long, just a trifle larger than the hole is to be. File or turn the pilot to required size, and file cutting edges on sides or end as required. Harden, draw at dark straw color, and use in the breast or hand drill. For bottoming a small hole in barrel, use stock the same size as the drill. Drill hole a short distance with twist drill, then use a flat drill cutting only on the end to scrape out the bottom. Flat drills may be made in any size for drilling holes in wood. Taper them sharply toward the shank, and shape the point into a wide V, beveling the edges from opposite sides.

The DRILL JIG shown in Figure 24 is worth its weight in gold. The best way is to make a pattern, or have one made in a pattern shop, then have the frame cast at a foundry. Bushings removable from the headstock are made to fit the different size drills you will ordinarily want to use. The hole in head and tail stock should be accurately machined, and the hole in tail stock fitted with a bushing to take a regular tapered lathe center, with cup point. The use of this jig for drilling Springfield guard screw holes and similar work is mentioned later on, and explained fully.

An adjustable drilling jig may be made at small cost as shown in Figure 25. This is a piece of 2 x 3 inch T-bar, with the top planed true and level. Holes are drilled at 2 inch intervals so that the tail stock may be set at any desired distance from the drill.

The CHECKING CRADLE, for holding stocks while being checked, is described and illustrated in Chapter 12.

TEMPLETS and their uses will be mentioned in Chapter 10, and elsewhere. It is advisable to have templets of butt shapes, also for magazine mortices, and similar uses that will be encountered more or less frequently. A number of different templates and their

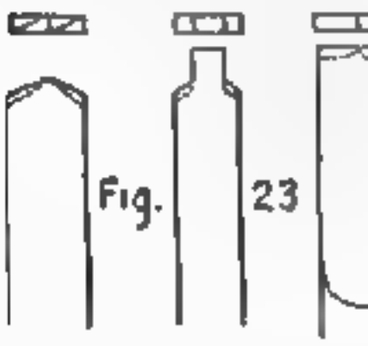

Fig. 23

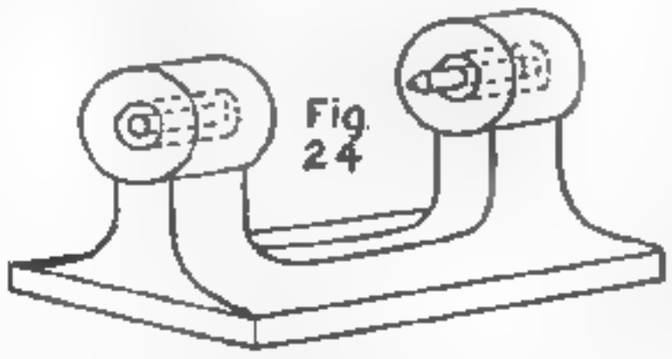

Fig. 24

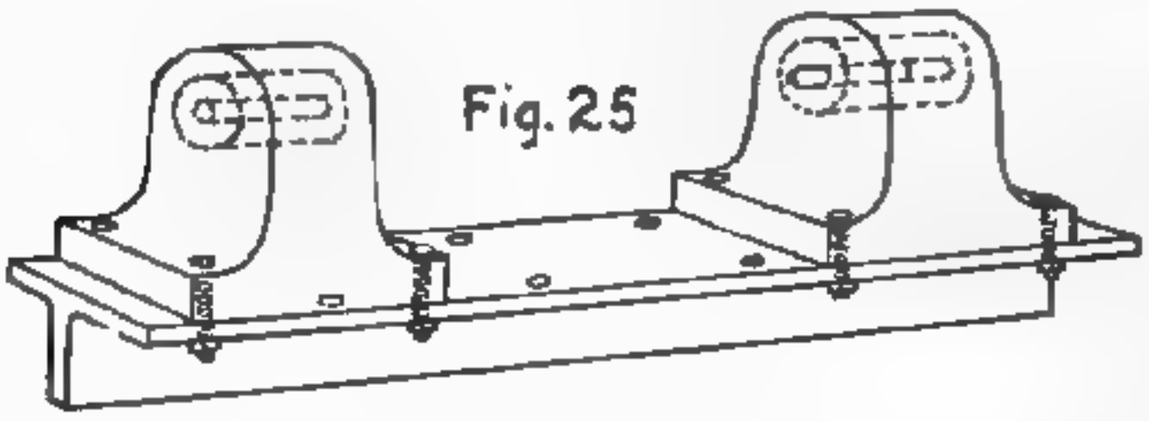

Fig. 25

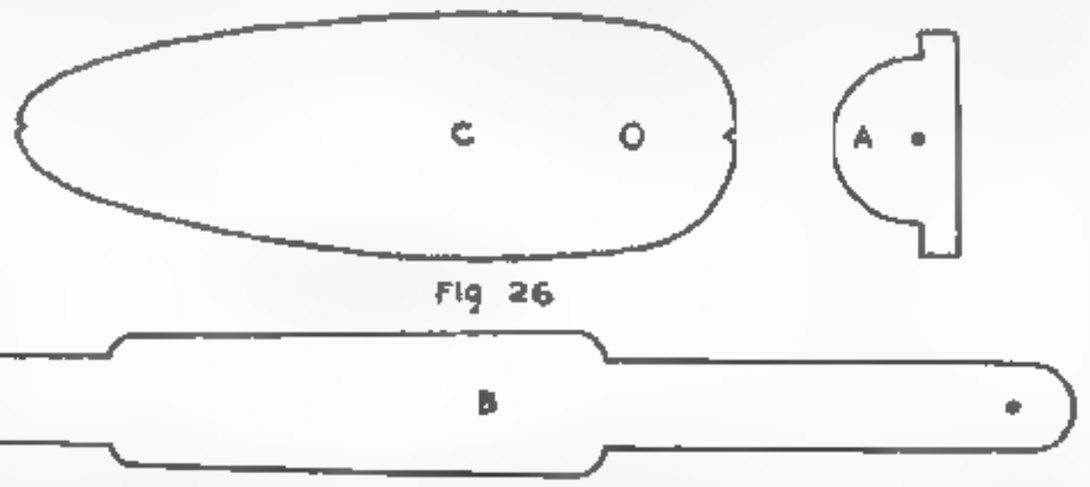

Fig 26

uses are shown in Figure 26. To make an accurate templet for a magazine cut, for example, take the old stock and coat the wood around the mortice with lampblack and oil. Press down on this a piece of clean stiff white paper. Remove the paper carefully and cut out on the outline left by the black. Paste this to a piece of

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spring brass about 1/32 inch thick, and file the brass carefully to shape. Try it often in the mortice in old stock, until it just fits snugly. Now file it about 1/32 inch smaller all round—this to give you a margin of safety and to allow for thickness of pencil point or scriber when marking around it. Do not make the screw holes full size, but locate their exact centers on the templet and drill them 1/16 inch. Lay the templet on the stock so the center line shows through these holes, and drive a brad into each hole to keep the templet in place while marking. The brad hole then gives you

the center for the guard screw holes.

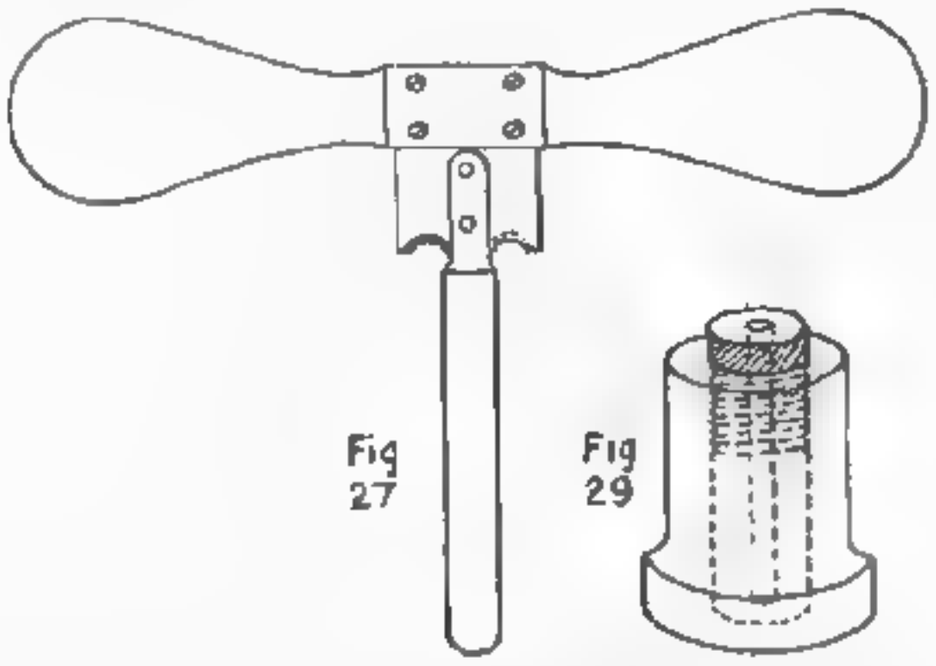

Fig 27

Fig 29

Small templets to serve also as depth gauges may be made to fit the receiver mortice at various points, saving you a lot of time by enabling you to cut down to the depth indicated by templet without frequently trying the action. Such a templet or gauge is shown in Figure 26 "a." This one gives the depth and shape of extreme forward end of receiver mortice. The round side is struck on a 5/8 inch radius. By means of this, one can go right ahead and cut away wood at this point until the side wings of templet rest on top of the stock blank.

MUZZLING CUTTERS: The crowning of a barrel muzzle is often puzzling to the amateur who has sawed off a barrel and doesn't know how to get the muzzle trued up square, with edge nearly rounded. In Chapter 24 I have described a simple method of lapping it true by means of graduated sizes of brass balls. The gunsmith who has frequent calls to cut off and crown Krag barrels, for example, will find the simple cutter shown in Figure 27 a convenience, for speeding up the job and reducing cost. The blade is made of tool steel 1/16 inch thick, with cutting edges beveled on opposite sides. The edge should be shaped and beveled, and the

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pin holes drilled after which the blade is hardened and drawn at dark straw color, then the sides ground flat and true by rubbing on an oil stone, and the cutting edges whetted. The pilot is also of tool steel, turned to shape and the end slotted on milling machine; then it is hardened, ground and polished to exactly .300 inch. It is attached to the cutting blade by two small screws as shown in cut. The handle is then made from machine steel, slotted and attached to the blade. To use place the barrel in vise with muzzle slightly lowered, so that no chips may work in against the pilot, and turn by hand. Finish by lapping inner edge of cut true with a 5/8" brass ball, as described in Chapter 24.

Brass balls, for lapping and trueing barrel muzzles, should be obtained in the following sizes:—3/8, 1/2, 5/8 and 3/4 inch diameter. Get at least two of each size in case you spoil or lose one. Drill a little more than half way through each ball with a No. 29 twist drill, and tap the hole 8 x 32; turn in a screw 1 inch long, cut off the head, and use the screw as a shank for holding.

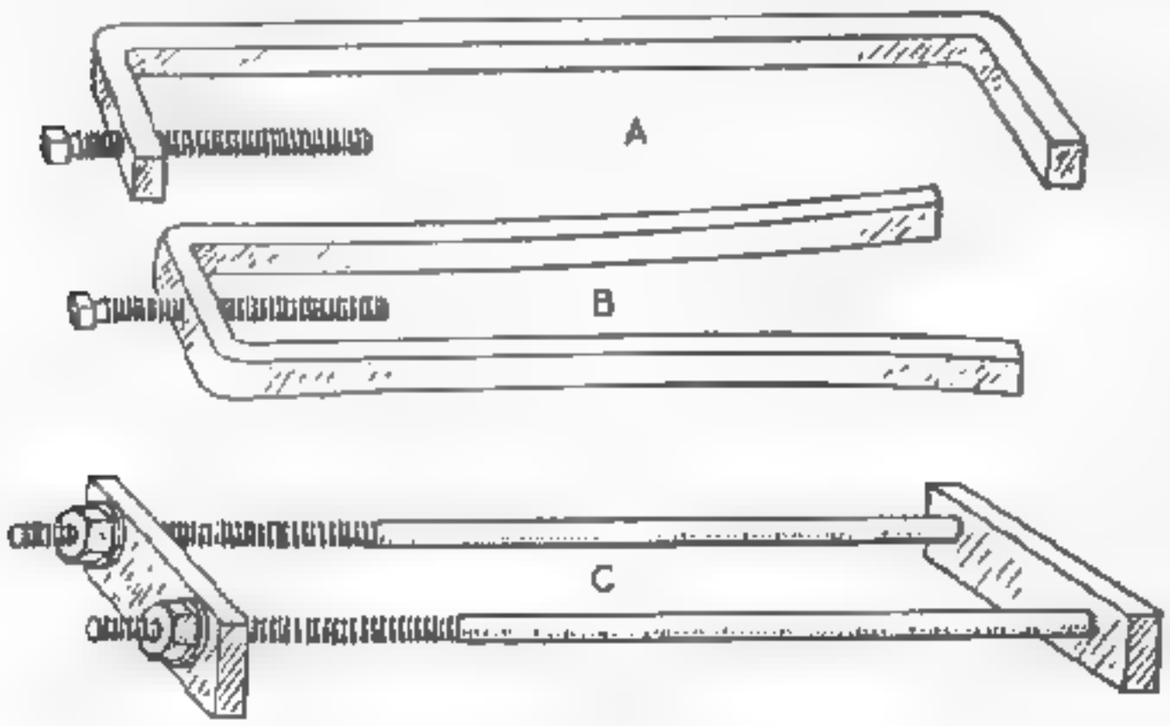

Fig. 28

CLAMPS: For attaching horn, ebony, ivory or other forend tips, there are two special types of clamp, known as the long C-clamp, and the Y-clamp or fork clamp. Figure 28 A shows the long C-clamp, which is made of a piece of 3/4x5/8 inch cold rolled steel heated and bent as shown, and one end drilled and tapped to receive a standard 3/8 inch cup-point set screw 3 inches long. These clamps may be made any length required, so that one end is in-

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serted in the magazine mortice of a Springfield, Mauser or similar stock, while the set-screw is tightened up against the block of horn or whatever is used for a forend tip. This clamp may also be used on the Krag by hooking the end into the magazine mortice on one side. A piece of heavy leather should be used under end of clamp to prevent damaging the wood.

The Y or fork clamp is also made from 3/4 x 5/8 inch cold rolled steel, bent to the shape shown, the distance between center of prongs being about 2 1/2 inches. This clamp is used for setting forend tips on stocks having no magazine mortice, such as the Model '73 Springfield. A strong vise is required for using this clamp, the clamp being slipped over the forend with one leg on either side; it is then placed in the vise, the jaws of which press the legs tightly against the sides of forend, after which the set-screw is tightened.

Sketch C, Figure 28, shows the butt clamp with which every gunsmith is familiar. This is used largely in stocking shotguns and single shot rifles. The end pieces are 1/2 x 1 1/4 inch cold rolled steel, with 7/16 holes drilled in ends. Into these place two long 3/8 inch bolts, and long enough to reach from the front of action to the butt of stockblank. The distance between the rods should be 4 inches. If long bolts cannot be secured use iron rods and thread both ends for nuts. When placing clamp on the work, tighten up the nuts on opposite sides a little at a time, to equalize the pressure.

Sometimes when using a hand drill it is difficult to judge when the drill is starting at a right angle to the surface of the work—drilling the screw hole in end of pistol grip, for example. This can be overcome by first drilling a hole the required size in a block of hardwood about 1 inch thick; have someone hold this tightly against the stock with the drill through hole in block, which will guide the drill straight into the work. If unable to drill the block straight, make up a number of small blocks, and take the drills likely to be used most to some shop having a drill press, and have the holes drilled. Three or four holes of different sizes may be drilled in each block.

A still more accurate method is to make a pattern and have it cast in iron like Figure 29. The bottom of this casting is then surfaced in the lathe, and a 5/8 inch hole drilled clear through and reamed to size. The upper end of hole is threaded for 1/2 inch. Now make several steel bushings to fit smoothly into the hole in casting, and leave the upper end of bushings large enough to thread into the threaded portion of hole. The bushings are then drilled in the lathe, with various sized drills. Each bushing should be stamped with the size of its hole. A jig of this sort will speed up small drilling jobs and avoid drilling holes at an angle. It must be held with the base tight against the work, and the drills used should be long enough to reach through the hole the required distance.

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CHAPTER 5

MATERIALS AND METALS NECESSARY

MODERN gunsmithing has taught the desirability of numerous small parts not formerly used on factory made arms. Many of these will be described in detail in later chapters. Since they are largely made of special material a brief discussion of some of the raw stock which the amateur or professional may require from time to time seems to be in order.

The common or garden variety of corner hardware store has little to offer in this line; the place to buy materials is from firms specializing in machine shop supplies, of which several are listed in the Appendix. It is well to understand exactly what you require before placing an order—because hardware men are not mind readers, and as a rule they know little enough about firearms. So make your instructions definite, and avoid disappointment and delays.

While I am not in the business of handling material for the trade, I receive many requests from amateur gunsmiths to supply

them with things they cannot buy locally, and although this necessitates a trip to a supply house I have always endeavored to serve these chaps to the best of my ability,—but it takes mighty close guessing sometimes to decide what they want, or whether they know themselves. Here is a typical request received a few days since: *"Please send me a piece of steel tubing 1/4 inch thick and large enough for a Krag barrel band."*

Now how could I possibly know what to send this man? He may have wanted to make a swivel band to be located at the same point where the military swivel band was originally placed; and for that matter, the rifle and carbine have their lower bands differently located. Or, he may have wanted to make a band to provide a rear sight base over one of the two screw holes in top of barrel. Again he may have had in mind a collar to ease off the abrupt jump-

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off from receiver shoulder to barrel. What he should have said was "—a band for the Krag barrel to be fitted so many inches from receiver"—then I would have had something to go on. On the other hand, had he been ordering from the supply dealer himself, this plan would have been a poor one, since the dealer probably wouldn't have a Krag barrel to measure, wouldn't have known anybody who had one, wouldn't know a Krag barrel from a vinegar barrel if he met 'em both in church, and wouldn't give a cuss whether he filled this fifteen cent order or not. It isn't hard to set the calipers on a barrel and measure its exact diameter where a band is to be fitted—then the man who fills the order knows what is wanted, or somewhere near it. I mention this merely as an illustration of the importance of being explicit when ordering stock.

Having mentioned BARREL BANDS, we may as well start this discussion with an outline of the materials from which they are made.

That mentioned most often in gunsmithing articles in magazines seems to be old hacksaw blades. Use blades if you want to—they make mighty poor bands, and the steel does not take a good blue to match the barrels. A yard strip of 1/16 x 5/32 inch cold rolled steel will keep you in band material for quite a spell and won't cost over a quarter. Moreover, it will blue to match the barrel. Heavy black sheet iron is about as good if you have some scraps of it, for a band should be dressed to about 1/32 inch thick when finished anyhow and need be no wider than 1/2 to 9/16 inch.

Cold rolled steel bar stock 1/4 x 3/8 inch square is good for the little block under the barrel to which the ends of band are fastened, and into which the swivel screw is threaded. A foot or so of stock this size may come handy for lots of small gadgets.

The best bands are made in one piece, and the best material for this type is the round seamless cold drawn steel tubing known commercially as Shelby Tubing. This material is also useful for a variety of other items, being perhaps the most generally useful of all material to the gunsmith. Shelby Tubing differs from pipe in that the latter is made from flat stock bent around mandrels and the edges brazed or welded; tubing, on the other hand, is drawn through dies and is without weld or seam, and of very smooth even grain and texture. It cuts nicely, takes a good polish, blues easily by almost any method, and may be bought in a wide range of sizes, both diameter and wall thickness. In the supply catalog before me there are four solid pages of Shelby tubing sizes, of which only a few need be considered here. It might pay the reader to secure a supply catalog listing this material, for future reference. Unfortunately it is listed by outside diameter and wall thickness, and since we are mainly concerned with the inside diameter, it becomes a case of "figger, Nigger, figger." In some sizes the wall thickness is quoted in British Wire Gauge measure; in others, in fractions of

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an inch. Here are some uses to which the various sizes may be put.

3/4" OD (outside diameter), 14 ga. WT (wall thickness)	Welded to blade as described later makes very good front sight ramp for Springfield. Other sizes could be selected for barrels of various sizes.
1 1/8" OD, 7/32" WT 1 1/8" OD, 5/16" WT 1 1/4" OD, 7/32" WT 1 1/4" OD, 1/4" WT	Will make swivel band for almost any sporting barrel where attached by screw through forend.
1 1/8" OD, 5/16" WT 1 1/8" OD, 3/8" WT 1 1/8" OD, 7/16" WT	For bands with swivel stud to be soldered on barrel ahead of forend, for most sporting size barrels.
1 1/4" OD, 1/16" WT	Makes plain band for breech of Springfield barrel to cover notch after removing original sight base.
1 1/8" OD, 3/32" WT	Makes band with base for No. 6 Lyman folding leaf sight to fit Springfield [illegible] at breech, covering notch in barrel.

—and so on. Whatever your fancy in inventive genius may conceive, you'll probably find some use for Shelby tubing, and you'll just as surely find the tubing available in a size suited to your purpose. Sight covers, and hoods, muzzle protectors or tompions, wells under grip cap for spare front sight—and numerous others.

Detailed instructions for making such parts will be found in Chapter 24. It must be remembered, however, that since most barrels are tapered the band must have a similar taper when finished. Tubing will stand a good deal of stretching, or it may be reamed to size and taper; so it is advisable to order it a trifle smaller inside than the finished band is to be. For barrel bands select tubing to fit the barrel two or three inches ahead of the location of band, unless the taper is very sudden.

The best material for swivels, connecting links for slings, and the like is BESSEMER STEEL RODS. These come in four foot lengths and cost little. The rods are lightly coppered to prevent rust, and this must be scoured off with emery cloth before using. Bessemer rods are stiff and strong, but designed for cold bending. They come in sizes from 1/16 to 11/64 inch by 64ths; and from 3/16 to 3/8 inch by 32nds.

1/8 to 9/64th inch is the size for swivels and strap links. The 9/64 size is an easy fit in a No. 25 twist drill hole, which hole also fits the pivot bar of the detachable swivel, thus we may standardize on this size for all sling fittings.

In the smaller sizes Bessemer rod also makes good pins for sights, etc., although drill rod is stronger, and available in a wide range of sizes.

The smaller sizes of DRILL ROD are useful in many ways. By keeping it on hand in a dozen or more sizes one is equipped to make any pins needed on short notice. The old damaged or broken pin may be measured by trying it in the Starrett drill gauge mentioned in Chapter 3; when you know the size, it is easy to try your

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stock of drill rod in the gauge until you find a piece the same size, cut off the length needed for the pin, round up the ends, and there you are. In a pinch I have cut off the end of a twist drill for a pin, trying different drills until the exact size was found. It beats a nail or piece of wire all holler!

Cold rolled STEEL IN FLAT BARS is used for the forms for bending swivels and links, and a few pieces six or eight inches long should be kept on hand for this purpose. Use stock 5/16 x 1 1/4 inches as a form for swivels to take the government sling; grind or file the edges round and smooth. A piece 5/16 x 7/8 inch wide is the right size for links to be used in straps fitting the detachable swivels. The making of these links and swivels is fully covered in Chapter 24.

SWIVEL SCREWS: The best swivel screw is of course made up on the lathe with the kind of head required. It is well, however, to have on hand a few 5/16 inch hexagon head cap screws, S. A. E. standard, for the rush job. Grinding the head round and drilling it from side to side for the swivel makes a fairly good job.

MACHINE SCREWS: Only experience will show what you are likely to require in the way of small screws, but the following sizes I have frequently found useful, and would suggest keeping a dozen or so of each size on hand, both filister head and flat head in all sizes.

10 x 32 8 x 32 6 x 32 6 x 40 5 x 40 4 x 40 3 x 48 2 x 56	These should all be iron screws: you will seldom or never have use for brass machine screws in gun work. Round heads should never be used—either a filister head in counterbored hole, or a countersunk flat head should be used.

You will need a few flat head wood screws from time to time in sizes from No. 5 to No. 8, and in lengths from 3/4 to 1 1/4 inch. A few flat head brass screws may be kept for emergency repairs on stocks. Sizes and lengths should be assorted. Always use iron woodscrews in tangs and other parts of the gun where steel is joined to wood. A No. 9 oval-head iron wood screw makes a first class butt plate screw.

A few brads, nails, etc., always come in good and should be found

about every shop.

ADHESIVES: For cementing horn to wood there is nothing equal to the old fashioned white flake glue sold in paint stores and occasionally in drug stores. Being made from hoofs and horns, it is perfect for this work. Brown or amber flake or stick glue has not proven satisfactory. Prepared liquid glue is all right for cementing sandpaper to wood wheels, and such jobs, but don't use it where strength and endurance are required.

Du Pont Household Cement is a pyroxilin compound, and the

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best cold adhesive I have ever seen. It comes in 25 cent tubes, and after drying is both waterproof and oil proof. Many glues will deteriorate and allow the joint to break open after prolonged contact with oil or grease. Du Pont Cement and some of its uses will be mentioned frequently in subsequent chapters. It is sold by many hardware and paint stores, and by the larger mail order houses.

Plastic Wood is a paste made of finely divided wood, with a binder added until it is the consistency of putty. It is used in a variety of ways, such as filling small holes, knots, etc., in repairing stocks. It will be mentioned later. It is sold in large and small cans at hardware, paint, and some drug stores. Buy the small can, as it may dry out if long unused after being opened.

PAINTS AND OILS: Shellac, orange or white. Useful for cementing sandpaper to wood wheels, and in various stock finishing mixtures.

Linseed Oil, Raw: For finishing stocks. Used alone, or with other ingredients. Specify Archer-Daniels-Midland Company's linseed oil.

Boiled Oil: There is no kettle boiled linseed oil on the market today. The compound boiled oil of the above company is perfectly satisfactory.

Varnish: Valspar, or Du Pont's Spar varnish, for oiling compounds. Sherwin-Williams hard rubbing varnish for full varnish finishes.

Lacquer: Du Pont's clear Duco lacquer for finishing stocks. Must be used in an air brush.

Alcanet root, for darkening oil mixtures. Gives a deep slightly purplish brown. Obtainable at drug and paint stores.

Oil Soluble Red: A dark red powder, useful for imparting a reddish cast to linseed oil. Obtainable at wholesale drug and chemical houses.

New Method Gun Bluer: Made and sold for bluing guns, and so used by those who don't know any better. Really useful for touching up the shiny end of a pin, point of a screw, etc., without removing part from gun. Also useful for painting the edge of a leaf sight which was filed down while on barrel.

Stain: Sometimes a stock will be very light in color, or have light streaks which look better darkened. Use Johnson's Wood Dye, or Ad-El-Ite Stains in Walnut or Mahogany to get the desired tint.

Turpentine: Occasionally needed in stock finishing compounds. Get genuine spirits turpentine, not turpentine substitutes sold by some paint stores. Hercules Steam Distilled is about the best.

Cup grease, No. 3—any standard make: Used in polishing stocks, also for greasing guns for shipment or storage. Melt it and throw in a handful of iron filings, keeping it melted for two or

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three hours, to free it of any acid. Then strain through cloth until clean, and let harden.

ABRASIVES: Sandpaper or Glasspaper, Nos. 1, 1/2, 0, and 00 will be needed in stock making and finishing. Garnet paper is better than sandpaper for use on wood wheels. Carborundum or Aloxite cloth in rolls 2 inches wide is far better than emery cloth for polishing barrels and actions. Use Nos. 1/2, 0, and 00. Emery cloth is better for final polishing as it breaks down more quickly. For an extremely bright finish, follow with Crocus cloth—this is made in but one grade, very fine.

Valve grinding compound, oil or water mix: If oil mix is used, the Carborundum compound is best. Use it for lapping barrels.

Emery, No. 120, for lapping barrels.

Pumice stone and rotten stone—powdered: Used for polishing stocks. Keep it in large sifter top cans for convenience.

HEAVY FELT, 1/2 inch thick: Used for padding vise jaws, and for rubbing stocks. Obtainable at harness shops and large paint stores.

WOOD FOR STOCKS: Should be purchased in ready cut blanks, or else in planks from 2 to 3 inches thick. See list of dealers in Appendix. After cutting out blanks, save your scrap for repairs and patches, pistol stocks, forends, etc.

TOOL STEEL, SPRING STEEL, etc.: The sizes and grades likely to be needed are discussed at length in Chapter 21.

Brass: A few heavy pieces of brass and copper are useful as soft bench blocks, for riveting, driving off military sights, etc. Pieces 1 inch thick sawed from 2 to 3 inch brass bars are very handy. They may be purchased cut as desired from machinery supply houses. Sheet brass and copper 1/16 inch thick should be kept for protecting vise jaws. Get soft brass if possible, as the hard sheets sometimes break when bent. Use 1/32 inch sheet brass for templets.

Solder in various grades may be had at hardware, machinery, and wholesale jewelry supply houses. Tin, lead, bismuth, etc., as well as spelter and silver solder may be bought from the same

Lead: Keep a few pounds of scrap lead—old pipe, etc.—for making very soft bench blocks and vise jaws, also for making barrel laps.

Horn, for forend tips, also ivory, must be purchased from one or two firms who import it in small quantities. Carabao or Asiatic buffalo horn is best. See the Appendix for firms handling this material.

Dowel rods in 3/8 and 1/2 and 5/8 inch sizes are convenient for making plugs for barrels, dowels for forend tips, stock patches, etc., and a few should be kept on hand at all times. Carried in stock by machinery supply dealers and some retail hardware stores. Oil, for sharpening stones, as well as lubricating actions. Marble's

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Nitro Solvent oil is the best light oil I know of for general use. Economical in quart cans at $1.50. Also used in oil bluing, as described in Chapter 20, and for "lamping" bright spots on barrels.

Chemicals for bluing processes, case-hardening, tempering and coloring metals. Many of these are not found in the corner drug store. See Appendix for list of dealers.

Bakelite and hard rubber in sheets 1/4 inch thick makes a good inlay material. Obtainable wherever radio supplies are sold. Hard rubber rod 1/4 inch in diameter is used for chasing rifle bolts.

Hard fibre, both red and black, in sheets of varying thickness, also tubes and rods is sold by machinery supply houses and electrical houses. Used in building up butts, and sometimes for making butt plates and grip caps. Hard fibre rod is better than brass or copper for driving out barrel sights, unless very tight. Will not mar the bl[illegible]

Buying materials is like buying tools—no use getting anything you do not need. It doesn't take long to get a good many dollars invested in a lot of stuff you may not use for a year, if ever. A knowledge of the right tool or the right material for the job will prove helpful to you in avoiding mistakes when the time comes to buy.

CHAPTER 6

FIRST STEPS FOR BEGINNERS

THE man who has never attempted even a simple repair on a gun and who is notoriously inadept with tools can scarcely expect to start in and turn out the class of workmanship found in the best shops. Gunsmithing, while a trade in itself, is really made up of the rudiments of other woodworking and metal working trades, with a number of specialized branches and operations of its own. For this reason the rank, raw beginner is often less handicapped than the man who is expert in one of the branches of mechanics applying to gunsmithing but who knows nothing of the others.

The beginner has nothing to unlearn; he does not, for example, expect to cut an action mortice in a stock with the same degree of fit that a carpenter would make in morticing in a door lock. He is not likely to make the mistake of the machinist who, understanding lathe work, blunders ahead and turns down a barrel without thinking of the "kinks" it is likely to acquire as stresses are released. The beginner meets all problems with a wide open mind, and accepts the instructions of men who are familiar with gun work; and therein lies his adaptability. In the course of time he will turn

out very creditable work, often far better work than the cabinet maker or the machinist, albeit he could not make a living in either trade.

If a man is entirely unskilled in the use of tools, so that he is forced to call in a carpenter to hang a screen door, or to drive into a garage to have the carburetor on his car adjusted, it behooves him to first of all familiarize himself with the mechanical trades into which he will delve to a greater or less degree, acquiring some knowledge of their terminology, and some acquaintance with the uses of various tools.

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As a first step in the right direction he should occasionally buy a copy of Popular Mechanics, Science and Invention, and similar magazines. In their pages will be found many helpful suggestions for amateur mechanics, from which he will in time absorb a certain amount of "atmosphere" and general understanding. If there is a first class hardware store in his town, he should cultivate the acquaintance of some salesman who knows tools, and will aid him in proper selection of things needed, and explain their uses in detail.

One of the very first things the beginner should do is to write to leading tool makers and secure their catalogs, and study them carefully.

These are more than catalogs—they are valuable textbooks. Besides the information they give, they are indispensable when it is necessary to order some special tool from a small dealer who never heard of it, and who may try to tell you that "there ain't no sich animule." Again, while the rather extensive list of tools named in Chapters 3 and 4 may seem like they should cover every possible requirement, there may be some job the amateur gunsmith wants to do that is not covered herein. Familiarity with the catalogs will enable him to select other tools for special jobs with certainty.

It is a good idea also to secure the complete catalogs of Sears-Roebuck and Montgomery Ward. These mail order houses handle many high grade standard tools, and can often ship them much quicker than the local small dealer can obtain them through jobber or manufacturer—and sometimes they sell them at slightly reduced prices. In using mail order catalogs, however, it pays to avoid the cheap "private brand" articles of unknown origin.

Dealers' catalogs should also be secured and studied carefully. In addition to the many standard tools listed, they also list much raw material, iron steel, brass, screws, etc. that will sooner or later be needed. Studying the catalogs not only familiarizes one with the supply of such materials, but enables him to order intelligently when the time comes.

But the most important thing of all to the beginner in the field of amateur gunsmithing is a thorough knowledge of guns and loads—not only his own guns and his own loads, but of all makes and models

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of guns, and all the cartridges he may want to use some day. To this end he should study carefully every catalog he can get his hands on, both American and foreign. Study the details of various actions; learn how they function; decide which are their good points, and their weak ones. Examine all the guns you can get hold of, and learn exactly how they work, and handle. Get all the cartridge catalogs you can and study them carefully—they are real textbooks, full of valuable information.

The chap who starts in to repair his first gun with only a hazy idea of what the various parts are for, and how the action functions will find himself as bad off as the boy who took his French harp apart to see what made the music—and likely he'll have enough parts left over to make another gun when he reassembles it. But, having acquired a good understanding of principles, and learned how much similarity there really is in guns of different makes and models, you will soon develop an intuitive understanding of mechanisms, so that you need not hesitate to disjuantle any action for the first time. You can drop the parts loosely together in a box, and it won't be like working a Sam Lloyd puzzle to put them together again.

Before attempting the more difficult jobs such as complete remodeling of a military rifle, adjusting the trigger of a fine target arm, etc., it is well to get one's hand in with a number of easy jobs and practice work where there will be no great loss if you spoil some material or parts. The practice you will get in making up checking tools, simple chisels, screwdrivers, etc., will stand you in good stead later. Learn trigger pull adjustment first on a cheap single shot rifle; let your first bluing job be an old pot-iron that is ready for the scrap heap anyhow—and if it turns out well, you're that much ahead.

An old wreck of a single barrel shotgun is a mighty good one to start your training on—and most single barrel shotguns are old wrecks. Don't be afraid of damaging it, because that's usually impossible. Fix up the trigger pull, replace damaged screws or pins, make a new spring or two where needed, perhaps a new firing pin; repair the broken stock (they're always broken somewhere), try your hand at checking it; put on a front sight, polish out the barrel (it'll need it) or try your luck at cutting off a few inches of the muzzle and re-choking by the overboring process described in Chapter 31. If the barrel is in very bad shape, cut it off ten or twelve inches, cut off the stock back of pistol grip, and make an "auto and burglar gun" of it. One of those "high power long range Texas Ranger guns" from Roars and Sawbuck will give the student-gunsmith more fun, as well as more real constructive experience, than a brand new stiff would give a medical student! And it will probably have more different things the matter with it, too.

This book is not intended as a mere compilation of shop kinks and detailed descriptions of specific jobs; rather, it is prepared

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with a view to its use as a text book, to be studied thoroughly. By familiarizing himself with the entire book before going to work, the reader should have a clearer understanding of the reason behind various instructions; knowing that he will be able to develop initiative to the point of devising ways and means of doing things which are not specifically described.

Woodworking tools, while not difficult to master, call for reasonable skill. The aspiring gunsmith should study the methods of expert woodworkers—not merely carpenters, but cabinet makers, musical instrument makers and repairmen, turners, and pattern makers. Of the trades named, perhaps the last more nearly approximates the skill required of the stocker than any of the others. The gunsmith can learn something from nearly all of the mechanical trades, but in "nosing about" for information, he should avoid those shops where "rough and ready" methods are the rule rather than the exception. Don't expect to see close machine work being done in the garage—the motor mechanic would be helpless on the simplest sort of gun work. Study the work of experts, and learn from them.

Finally be sure that your knowledge of firearms is practical and not theoretical. Be sure you know *what* you want to do, and *why*, before you worry about the *how* of the matter. Study the works of Whelen, of Crossman, Askins, Hatcher, Fitzgerald and other authorities who know whereof they speak. Before making up your mind to risk long hours of time and hard-earned dollars' worth of materials to prove your theories—check up on their practicability through the knowledge of others, whose experience has covered a wider field than your own.

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Chapter 7

GENERAL SHOP PRACTICE AND USE OF TOOLS

MUCH of this chapter will be of no interest to those already having a knowledge of common tools and their uses; it is written largely for the benefit of the beginner, who has spent his life working with head rather than hands; and who finds himself awkward in the use of even the simplest tools, and whose knowledge of their uses and possibilities is limited.

Woodworking tools will receive first consideration. Having "tooled up" his shop, the amateur is likely to believe he is ready to go to work. But not just yet. Edge tools of all kinds usually come from the factory ground, but not honed or whetted to a fine working edge. It is necessary to understand, first, how to properly condition new edge tools for use; and second, how to keep them in tiptop shape for finest work.

The bit of cutting blade of your jack plane will do as a first illustration. Remove it by unlocking the cam clamp of the iron holder on the outside. Remove this holder, and you will find the bit can be lifted out, attached by a large set-screw to its guard. Loosen this screw, using the edge of the bit holder as a screw driver. Note that the sharp edge of the guard was set within about 1/16 inch of the edge of the bit.

Now study the bevel ground on the bit. Note that it is about 1/4 inch wide, and slightly hollow ground. Being made primarily for carpenter work on soft wood, the bevel of the edge is usually somewhat shorter than is needed for best results in hardwood. However, if you have no grindstone, leave the bevel alone for the present. Later, if you have access to a good sand grindstone—not an emery wheel—you can grind the bevel back about 1/32 inch, but not more than that.

You will note that little if any WHETTING has been done

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on the edge. Take your combination coarse-and-fine carborundum stone, and set it on the bench with the smooth face up. Apply a few drops of oil to center of stone. Hold the plane bit in both hands as in Figure 30, with the heel of bevel resting on the stone, as in "A," Figure 31. Now slowly lift the upper end of bit, tilting it forward until you feel the edge touch the stone, and the oil squeezes out in front of this edge. Figure 31-B. The heel of bevel is thus very slightly lifted from the stone, so that only the edge will be sharpened. Maintaining a firm but not too heavy pressure,

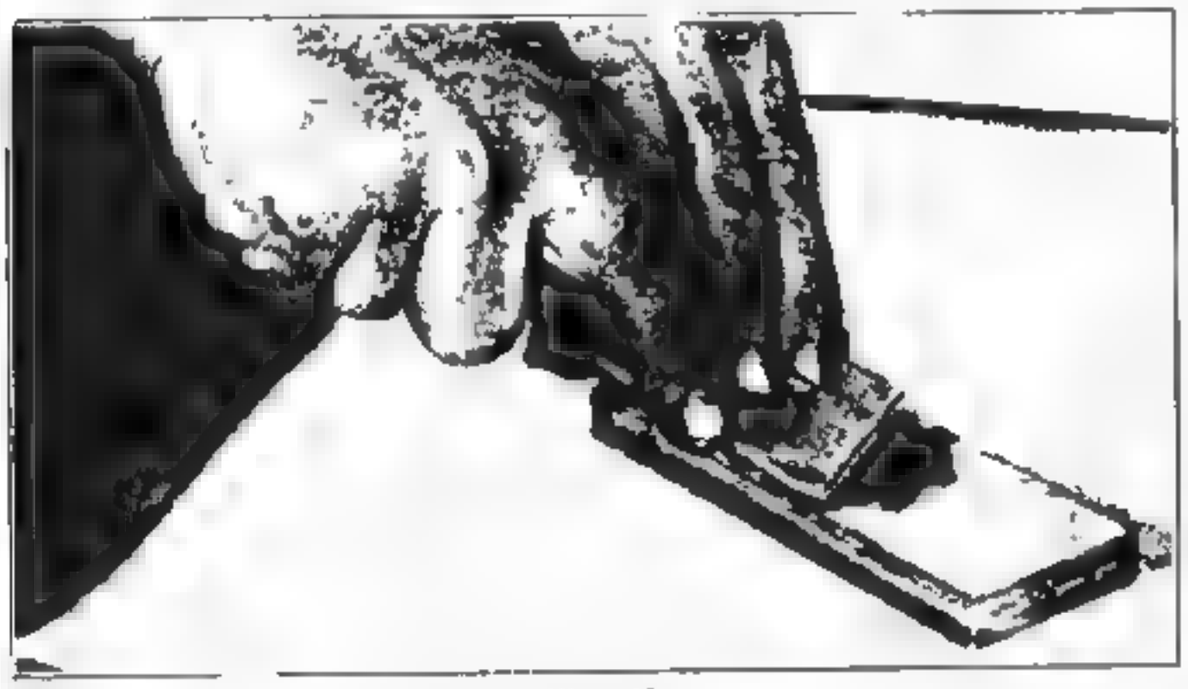

Fig. 30

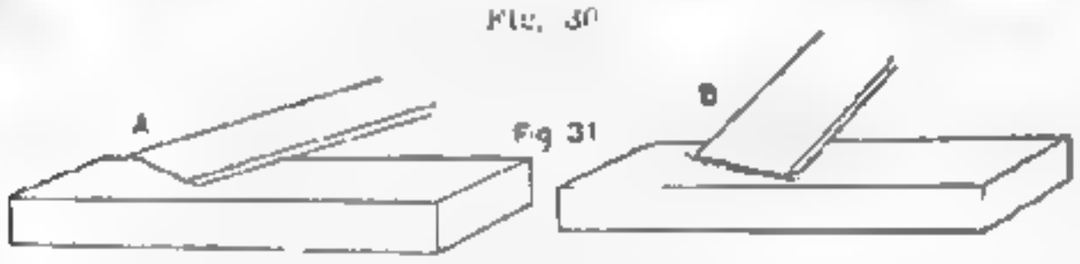

Fig 31

and holding the wrist joints stiff, so as not to change the angle of the bit with the stone, move the bit in a long oval stroke, with greatest pressure as you go *against* the cutting edge. After a few strokes lift, wipe off the oil, and examine the bright whetted edge. This short bevel should be about 1/32 to 3/64 inch wide, and should be even clear across the width of the bit. If it tapers off toward one corner, it shows the pressure is too great on the opposite corner. Try again, until you have a smooth, even narrow bevel clear across the edge, with a fine "wire" edge turned on the flat (unbeveled) side of bit. Lay this side *perfectly flat* on the stone, and rub back and forth until this wire is whetted off. It will not all be removed but will be partly turned over on the bevel. Reverse and whet the beveled side as before, removing more of the wire and turning the rest on the flat side. Continue whetting

the two sides alternately until all the wire is removed and the edge feels sharp to the fingers. Remember, the flat side of the bit must not be beveled the least bit.

Now replace the carborundum stone with the Lily White Washita oilstone, and whet the bit on both sides in the same manner. Be sure to keep the same bevel on edge each time you whet it, and always bring the heel of bevel against the stone first, then tilt it until the heel is barely lifted from the stone, and oil is squeezed out in front of the edge. This stone will produce a finer wire edge, which is carefully whetted off, first one side then the other.

Test the edge by wetting the thumbnail and drawing the bit across it. No danger—it won't cut through the nail at all. If very sharp and smooth, as it should be, you feel it "take hold," and any roughness or dull spots will be noted instantly. Continue whetting on the Washita until the edge is perfectly smooth, sharp and true. At this stage it should shave hair from your arm almost as smoothly as a razor. Now strop the edge on the flesh side of a piece of heavy leather, nailed to a piece of wood, or one end of the bench, or other suitable place. Be careful not to rock the blade in STROPPING, thus rounding the edge. Note that in whetting, most of the cutting is done *against* the edge, while all stropping is done away from the edge.

A splendid tool strop is made by bolting together a number of narrow strips of heavy leather, such as saddle skirting, with slender stove bolts. Sandpaper both sides smooth and even. In whetting tools, the oil and grit from the stone works up into a greasy paste. Always clean this from the stone immediately, and spread it on one side of the strop or leather block. Use this side for the first stropping, and finish on the clean side. When properly sharpened the plane bit or any other wood working tool should cut a hair cleanly as any razor. You can't begin to appreciate the value of this kind of an edge until you have used it and then try to use the kind of edge usually found on tools! It's the same difference as driving a flivver with three cylinders missing and the gas tank empty and two flat tires, when you've been driving a new Cadillac.

The foregoing will apply to all plane bits, though the angle of the bevel differs somewhat for different type planes. For example, a block plane bit lies down much flatter than that of a jack plane, and the bevel of the edge is wider accordingly.

When assembling the plane, reverse operations used in removing the bit, and note carefully how much of the edge of bit projects through the slot. There is a long lever under the bit by which the blade can be shifted from side to side, to even up the projecting edge. The bit moves in the opposite direction to the lever in some planes and in the same direction on others. Shift it until it is perfectly even, and draw it back with the adjusting screw until it *barely* projects below the surface. Some mechanics adjust plane

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bits entirely by feel; a better way for most people is to hold the plane bottom up in a good light, and sight along the surface. Any variation in depth of bit at either side will be instantly noted.

In USING THE JACK PLANE most beginners (and also many mechanics who should know better) will turn it at an angle on the work, instead of pushing it in a straight line. The reason for the long body of the plane is to carry the cut in a straight line, to true up and straighten an unequal edge. Turning the tool sideways permits it to follow the curves and hollows, thus failing in its purpose. Holding it straight on the work is particularly important in straightening up the top line of a stock, which is one of its principle uses in gun work.

Start in with the lightest possible cut—the bit scarcely scraping the wood. After two or three strokes, if it does not take hold better, set the bit very slightly deeper. Thin, almost transparent shavings give you better control of the work, and produce a better job.

If you find you are cutting against the grain, reverse and work from the other end. When the grain runs "every which way" as it often does in stock blanks, just do the best you can.

When using the smooth plane to merely clean up the side of a rough piece, it is often permissible to turn the plane at various angles to get at the hollow places. Sometimes, in very curly wood, the smooth plane will cut better *across* the grain than it will from either end.

In starting a stock job, one flat side—usually the right side, should be planed perfectly flat and true as a working surface from which

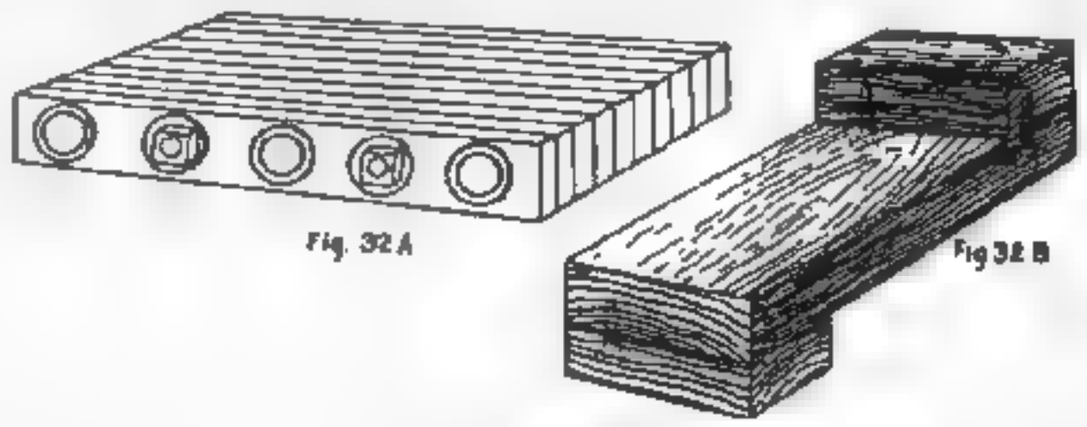

Fig. 32 A

Fig 32 B

the center line is run with the marking gauge; and on this job use the jack plane, and sight along the surface to be sure it is kept in a straight line.

The block plane was made for cutting across end grain; yet it cannot well be used for such jobs as truing up the butt of a stock,

because it invariably chips the edges at end of cut. It is a handy little tool however for many small jobs, such as shaping up patches, squaring up ends, etc. Make a bench-hook of hardwood as shown in Figure 32B, and use the plane on its side for small work, which is held in the hook. This device is also called a "shoot board."

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Never stand a plane upright on the bench when through using it. It should always be laid on the side to prevent the edge becoming damaged. Wherever you keep your planes when not in use, either lay them on their sides, or else have them blocked up with thin strips of wood.

Never drag the plane back on the edge of bit during the return stroke. Either lift it completely off the work, or at least lift the rear end, letting the frame ride on its point. Nothing ruins the cutting edge so quickly as dragging it back on the work after the cutting stroke.

CHISELING: Next in importance to the gunsmith come the chisels used in stock inletting. I have mentioned the J. B. Addis

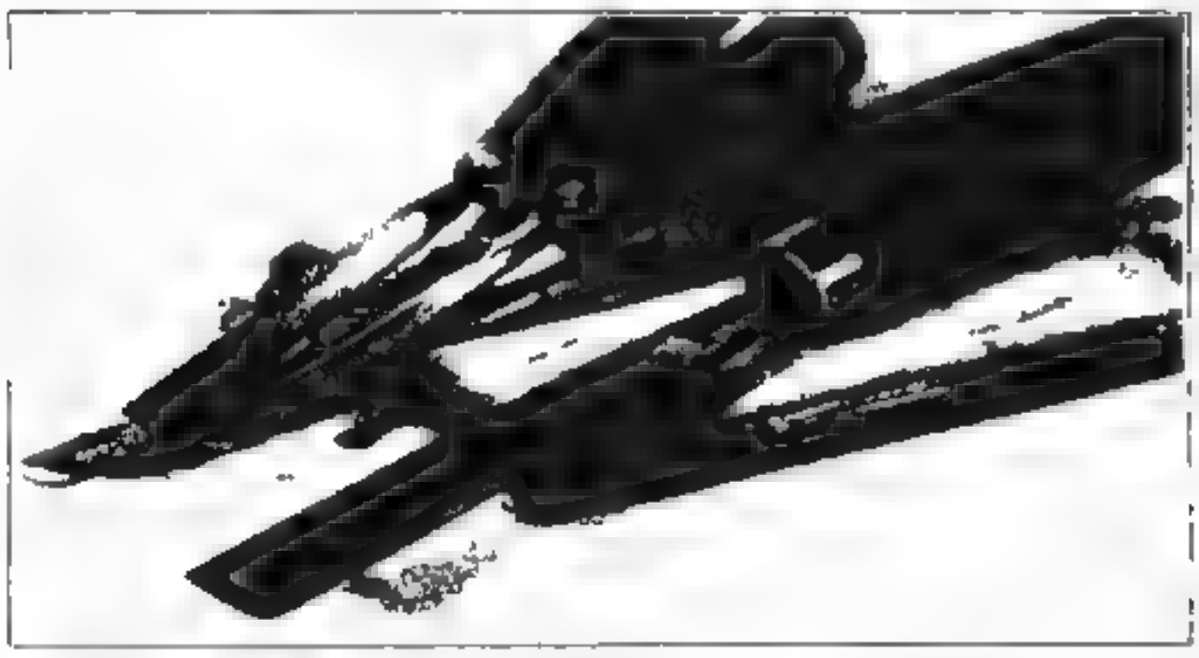

Fig. 33

wood carving chisels as being best for this work. If you do not have these, then your carpenters' chisels and gouges must be ground with a much longer bevel than the carpenter or cabinet maker uses—grind the bevel from half again to twice as long. Also, it should be a rounding bevel instead of straight.

Carving chisels, or any others used for stock making, should have a double bevel. The most pronounced bevel is of course on the bottom or outside; but the top or inside of blade should also be slightly beveled, contrary to the custom of other woodworkers, who bevel chisels on one side only, like plane bits. And both bevels must be very long, gradual, and slightly rounding—the bevel running off into the line of the blade without any definite stopping point. Figure 33 shows a number of carving chisels properly sharpened.

Your chisels will come to you only rough ground, probably with a thick unfinished edge. Use the coarse side of the combination

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carborundum stone first, and carry the bevel well back. Do not have any short bevel at the extreme edge as you did on the plane bit. Sharpening the outside or bottom causes a wire edge on the inside. This is worked off with the round edges of the carborundum slip hone first, then with the Washita and finer slips, the inside being gradually beveled, but not nearly so much as the outside. Finish both sides on the Washita stones, then strop both inside and outside on leather. For the hollow chisels or gouges, bend or fold a piece of leather to fit into the curve, and rub the leather away from the edge, not against it.

Carving chisels must be as sharp as human effort can make them They must be so sharp that they will make a smooth, polished cut *against* the grain if necessary. The wood carver's test for sharpness is to try the chisel or gouge *across* the grain of a piece of very soft, spongy pine or "deal." It is not sharp enough for this purpose until it will make a smooth cut in this manner without the least suggestion of tearing.

The slip stones should be kept handy, also the strop, and edges of chisels touched up frequently. Much time is saved, and split or rough cuts are entirely avoided.

Fig. 34

Figure 34 shows the best method of manipulating the carving chisels. The hold will vary slightly with the nature of the work

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but both hands should be used whenever possible, to give best control. Figure 81 shows an easy way to cut out a deep channel, such as the guard channel in a rifle stock, when impossible to get in line with the cut. A hollow chisel is used across the grain, which prevents tearing or splitting; the humps are worked out in the same manner as the rough cutting is done, and the bottoming tool is used to level up the bottom of channel. Wood carvers rasps, or "rifflers" are also handy for this work.

THE DRAW-KNIFE is an accepted tool of the carpenter, but should be used advisedly by the gunsmith. In Chapter 11 I have not mentioned the draw-knife in connection with stockmaking, for the reason that I very seldom use it, nor do I consider it necessary. The only time it can earn its keep is when used for roughing off the corners of a very straight grained blank, on which there is no chance of running in too deeply. The draw-knife is a perverse instrument, following the grain of the wood with the tenacity of an old millionaire after a chorus girl. Before you realize it, there's a bit peeled out, just a sixteenth of an inch perhaps, deeper than you wanted it.

There are stockmakers, however, who use the draw-knife with consummate skill, doing nearly all of the shaping with it. I can see no reason for this, as a good cabinet rasp will do the job just as rapidly, and with absolutely no danger of going too far.

The American workman holds the draw-knife straight across the work, and pulls it toward him by main strength and awkwardness, ripping and tearing off the kindling at a great rate. His draw-knife has a short bevel, and is seldom sharper than the law allows. The Englishman, on the other hand, considers it as a cutting tool; he grinds a long bevel back on the blade, and even bevels the bottom side slightly also. He then stones the edge until it is razor sharp, and in using it, holds it at a decided angle on the work. The left handle is further from his body than the right, and instead of giving it a straight pull, he uses a curving stroke, bringing the right hand in closer to the work at the end of the stroke. Thus instead of ripping and splitting the wood, he pares it cleanly, even cutting across and sometimes against the grain without splitting. He didn't learn this technique in a day or a week, however; such workmen are usually apprenticed to their trade very young, and their skill comes with their years of experience. At that, a man with a good rasp will shape up his stock just as quickly as the English workman will with his draw-knife.

The SPOKE-SHAVE is a cross breed between the draw-knife and the plane. The bit should be sharpened like a plane bit, and set in the same manner. Set it for a very shallow cut. It is useful for trimming down the work after the draw-knife, and is used in the same manner,—providing you like the tool. I can do three jobs with a cabinet file while I'm doing one with the spoke-shave, and do them better.

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SAWS: The average man uses a saw very clumsily—and this

is nearly always partly due to the fact that he has a very poor tool to work with. The Atkins or Disston saws mentioned in Chapter 3 will do good work from the start, and are easy to keep in shape. Saws for hardwood should have rather finer teeth than those for pine. Keep them well sharpened, and with medium set.

A saw vise costs only about 75 cents, and is essential for sharpening saws. Clamp the saw about 3/8 inch from the edge. Run a flat mill file lengthwise over the teeth one or two strokes, to equalize their length. Then take a slim taper saw file, set it in the first tooth and make a light cut. Note whether this is at the same angle as the tooth was cut originally. Shift the position of the file until it is, then hold at this angle throughout the job. File every alternate tooth from one to three strokes as required to bring them to sharp points; then reverse the saw in the vise, and file alternate teeth from the other side.

The saw set is a pair of tongs used for bending the teeth slightly outward to give clearance to the cut, and prevent the saw binding in the wood. Good dry hardwood requires very little set to the saw. The Atkins saws have the back ground about four gauges thinner than the teeth, so that they run easily with minimum set.

The saw is held in the vise for setting just as it was for filing. Set every other tooth, then reverse the saw and set the ones you missed from the other side.

Note the difference in shape of teeth on different saws. The cut-off, or "cross cut" saw has V shaped teeth which chop their way through the wood; the rip saw has chisel teeth, which are filed nearly straight across, while the others are filed at a decided angle. A circular is usually attached to a new saw advising the kind and size of file best adapted to filing that particular saw, and the manufacturer's instructions in this matter should invariably be followed.

Control of the saw in following a line is something that must be acquired by practice. Hold the saw as you would a revolver or pistol, but with the right forefinger extended alongside the handle and pointing forward, giving much better control of the blade than if all fingers are inside the hand hole.

In shaping up a stock, after the blank has been inletted, much time can be saved by sawing the butt to the approximate outline of the finished shape. In like manner, the rip saw may be used to rip off the corners—if it begins to run in too deeply, just saw off the piece and start a new cut slightly outside.

Always mark the wood on all four sides previous to cutting with the saw. Thus you can watch the cut and avoid running in. The thickness of a saw permits some slight change in direction during a cut; thus if the cut is running the wrong direction, the blade may be forced slightly the other way, gradually bringing it back into

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line. Too much of this twist, however, will make the saw stick. If the cut runs far to one side, stop and cut off the piece as far as the cut goes, and start over again.

A back saw is the thing for use in a mitre box, as the blade is held straight and rigid by the heavy strip of metal on the back edge. The back saw has very little set, and runs easily in a straight line. For the few jobs on which it will be needed, the gunsmith may dispense with back saw, using the cutoff saw instead.

AUGUR BITS. Always buy the best obtainable, as a cheap bit is the sorriest tool on earth. They must be kept very sharp for clean work in hard wood. Use a regular augur bit file for sharpening or, some of the small die-sinkers' files will be found even better on small bits. A medium long bevel should be filed on upper side of the cutting edge. Do no filing whatever on bottom side, except one small flat cut with a fine file to remove the burr. The side lips should be filed entirely from the inside—any filing on outside of lip will reduce the cutting diameter, causing the bit to stick in the hole and pull out the spur. The spur should have a very coarse thread —the fine thread spur is useless, as it pulls out and will not pull the cutting edges against the wood. Forstner bits are very difficult to sharpen. They are usually quite sharp when purchased, and as their use is limited, the edges should be left alone as long as possible. The best way to sharpen them is with a dental engine and a carborundum point stone. Expansive bits are sharpened in the same manner as regular augur bits.

In the matter of bit braces, about one in a hundred, apparently has the chuck centered in line with the center of form. This causes most of them to run wobbly. Sometimes this wobble is caused by the bit not being straight, and all bits that are sprung should be promptly discarded. The solid center bits are stronger and generally better than the flat twist in this respect. Keep returning your brace to the dealer for exchange until you get one that is reasonably well aligned. One mistake the beginner makes is to buy the largest sweep he can find—which means a brace that is rather springy, when it should be stiff. Select a heavy brace, with a large, strong chuck, and a sweep of not more than ten or twelve inches—ten is plenty. The Miller's Falls No. 872 brace has a 10 inch sweep and is stiff and strong—besides having a chuck that will hold. With such a brace one can exert all the pressure necessary for boring a 6 or 7 inch hole in the butt of a stock, with little danger of the wobbling cut which causes the bit to run out sideways. Before starting a hole in hardwood, always mark the center very accurately and punch deeply with a sharp prick punch.

Twist drills are useful in the brace or hand drill for boring small holes in wood. For this use they should be ground to a point about 1/3 to 1/2 longer than when used for metal.

RASPS. There are two shapes of rasp, one, equivalent to that

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of the half round file, known as a wood rasp; the other being thinner, and with a much more flat curve on the one side, known as a cabinet rasp. The latter is best for gun work. In using it, hold the handle in right hand, and the point in left hand. As you push forward also move the rasp sideways, making a diagonal stroke, the rasp being turned at an angle of about 30 degrees with the work. This gives a very even cut over two or three inches of surface, whereas pushing the tool straight in line would merely cut a groove its own width. Always use the rounded side for the first roughing cuts,

Fig. 33. Manner of using rasp.

using the flat side when the stock has been reduced to almost its final shape.

The cabinet file is similar in shape to the rasp, and is used in the same manner. Having finer teeth it makes a smoother cut. This is the tool to use for the final truing up of the surface of a stock, before the first coarse sanding. Some stockers follow the cabinet file with another cut using a common mill file—but this cuts very slowly on wood, and the file teeth also clog badly. Very light finishing strokes with the cabinet file will leave the wood in very good condition for the sandpaper.

FILES AND FILING. Some day I hope to know enough—provided I live long enough—to write a book on this subject alone. It is one of the fundamental mechanical subjects, and one which might easily require the space of this entire volume—and still not tell half the story. The file is the basis of practically all cutting operations in the machine shop; the milling cutters, profile cutters, etc., are really files; a broach is a file; the cutter on a rifling head is a single tooth file—and so is the cutter on the planer or shaper. Even the lathe operations are based on the fundamental principles of filing—the tool being the file, which is held stationary, while the work is revolved against it.

Given the right files, a first class mechanic can make by hand almost any part ordinarily made on machines. Slower—yes; but it can be done. Such a man knows and understands that the file is an

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important cutting tool, designed for shaping and forming; while the layman usually thinks of it as something to scratch or smooth the surface. He seldom considers that there is a right file for the job at hand, and knows only that there are flat files, "three cornered" files, and rattails. He usually goes into the store, and says "Gimme a small file;—Oh, about six inches, I reckon; yeah, that'n'll be all

right." Then he takes it and skims over the surface of whatever it is he is spoiling, often making no impression to speak of, and at other times misshaping the article badly.

If I included too great a number of different files in my recommendations in Chapter 3, it was because I realize the need for various shapes and sizes, and know how the possession of the right file for the job will speed up work and save cost.

One of the first lessons to be learned in the matter of filing is to take all the short cuts possible—otherwise the job becomes so tedious that one tires of it and gives it up in disgust. I have seen a man scouring away for three hours on a bar of steel with a fine mill file, trying to take off nearly a quarter inch of metal. It never occurred to him, for some strange reason, to saw the strip off close to the line with the hacksaw, and finish with a file.

Before going into these short cuts however, the amateur mechanic should first know how to use a file; to make his strokes in a straight line, without rocking the file, resulting in a perfectly flat surface instead of a rounding one. Once this is learned any man can acquire proficiency with the file; and until and unless it is learned, his work will be of the crudest, most amateurish type.

Whatever it is you are filing, it must be held very firmly in the vise. When a part wobbles about this way and that, you cannot file it correctly. Use leather, brass, sheet lead or whatever is necessary, to hold it, *but set it up solid*. Lay the file evenly on the flat surface of the work; hold the handle in the right hand, the point in the left, and swing the arms forward in a full body movement, keeping the file constantly in the same plane. Despite your best efforts the file will rock, and the surface will be rounded. No matter how flat you think it is, just hold it up to the light with a small square or straightedge touching the surface, and the curve will be plain. Only practice, with constant thought to the direction of the stroke and the movement of the hands, will correct this fault.

I am a firm believer in coarse, fast cutting files. I never could see anything gained by prolonging the job with a slow tool. If there is 1/32 inch or more of metal to be removed, I will use a medium cut bastard file until I almost reach the line, then go ahead with a medium fine single cut or mill file, and finish with a fine cut Swiss. Getting rid of surplus metal quickly relieves much of the monotony—and believe me, even the coarsest file doesn't reduce dimensions nearly so fast as it seems. Measurements with a micrometer after a few cuts will show how fast the work really progresses—and it is

surprising how many cuts with a new sharp mill file are needed to reduce the thickness of a piece of cold rolled steel a thousandth of an inch.

The ingenious mechanic simplifies his filing in a variety of ways. For example on a piece of uneven shape, such as the receiver of an automatic pistol, he will block it with square bars of cold rolled steel between the receiver and vise jaws until the work is held as tight as a square bar would be. No worry now about the thing slipping and the file making an incorrect cut. One kink I have found most useful when making small parts from solid stock is to keep a small cheap cast-iron vise, costing only a dollar or so, and use it partly as a filing jig. Having marked on the material the line to which the filing extends, the piece is placed in the vise with this line just below the edge of the jaws. Now I can use a coarse sharp file and rough off metal without thought of going too far, until the file hits the edges of vise jaws. I can then raise the work slightly in the jaws, and finish-file with a finer-cut tool. I keep the vise jaws filed straight and flat on top, which enables me to keep the surface of the work very true. It makes no difference if the file cuts or mars the jaws—I simply file them true again later. And it takes a long, long time, and hundreds of jobs, to wear even a small vise away.

When the file reaches the vise jaws it is nearly impossible to round a surface of the work held between them, as the jaws keep the file dead level, or if it should rock slightly, it is the outer edges of the jaws that are rounded, and not the work.

This stunt is also useful when cutting irregular shapes—for example the shaping up of a barrel band, like Figure 36. A description of this job from start to finish will include a lot of file technique which can be adapted and applied to other jobs.

In Figure 36, A shows a piece of thick walled Shelby tubing cut to about 5/8 inch long. The first thing to do is level up and smooth one side, which is done in a moment by holding it against the side of the emery wheel. Now saturate a small wad of cloth or waste with copper sulphate solution, a bottle of which should be on the bench at all times. Rub this lightly over the bright clean surface until well coated with copper. Without thus coppering the work, it is difficult to mark lines on it that will show clearly. Now lay the blade of the centering square across this face, with both legs resting against the outer edge (be sure there are no burrs on edges to throw the square out of line) and scribe a center line across the face of the ring. All measurements are to be taken from this line. Let us say you want a swivel screw stud 1/2 inch wide on this band. With dividers lay out dots on either side and 1/4 inch from the center line, and connect these dots by lines as shown at B, Figure 36. C shows the method of projecting the center line and two sides across the edge of stock with a small square. Having

done this, "face up" the other side of the emery wheel, copper it and project the center line across it with the centering square; from this measure off and rule in the side lines of stud, as you did on the other side. Now set the piece in the vise, and with the hacksaw lop off excess metal, as shown by dotted lines in D, Figure 36. Now slide the piece down in the vise so that just enough metal projects below the upper edge of jaws, to give the depth of fillet wanted where the stud joins the band, and with a rattail file of the right size, file down in this fillet until the file touches the vise jaws. Be careful not to make this fillet cut run through the line

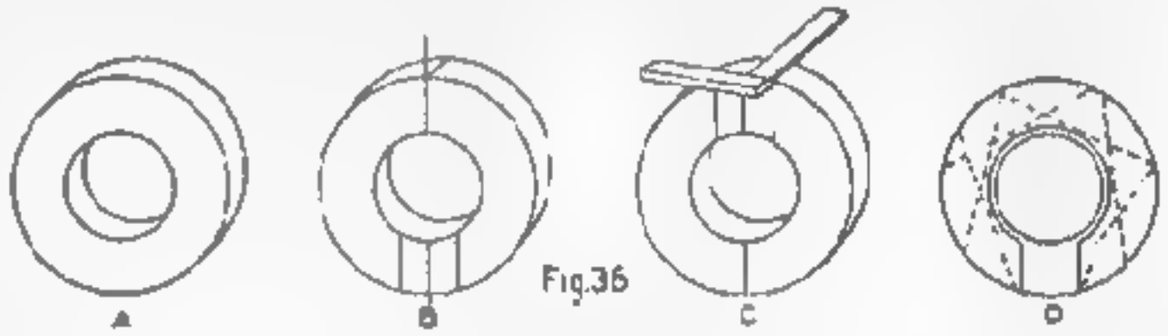

Fig.36

of the side of the stud—bear pressure to right or left as required, or shift the position of the piece in the vise slightly if necessary.

Cut the fillet on the other side of stud in exactly the same manner; then reset the work in the vise so that the side lines just meet the edge of vise jaws, and file down to these lines. Thus the stud is quickly roughed to final shape, needing only smoothing up with a finer file, and slight rounding of the sharp edges.

The band is now clamped edgewise in the vise and the sharp corners of the saw cuts roughed off with a double cut flat bastard file, until the band portion is about 1/16 inch thick. For this work use the file in any direction that is most convenient—around the band, or across it. If you have an emery wheel, some filing may be saved by roughing off the saw cuts on the wheel, the band being held in the fingers on the tool rest of the grinder, and turned about as required. The band is now ready to fit and finish as described in Chapter 24.

When making small parts to replace broken action parts, great care is necessary in the filing to shape the new parts exactly like the old. A hammer, or trigger, for example, must be accurately shaped or it will not work with the other parts in the action. The best way to accomplish this is to first work down the stock for the new part to nearly the correct thickness; tin one side thinly with soft solder; tin the pieces of the broken part, lay them together in correct position on the new piece of stock, and sweat them on. Then grind or file the metal down to the exact outline of the old part. If the part has a hole through it for a pin or screw, this should be drilled through the hole in old part before shaping up.

When there is such a hole, and the shape of the part is not com-

plicated, the sweating is omitted in some cases, by first drilling the hole, then inserting the drill through the hole in the old part and the stock for the new one, and thus holding the two together in the vise while filing. After finishing, a little heat will melt the solder, separating the new part from the old one, when it can be polished up and tempered or case-hardened as desired.

FINISH FILING: Most working parts can be filed so smooth that little if any polishing is necessary—in fact, the polishing is often omitted entirely. After the rough cutting is over and parts brought within ten or twelve thousandths of final shape and dimensions, finish shaping with a single cut mill file. It will often prove desir-

able or necessary to grind the teeth from the edge of a file to adapt it to the work—and sometimes to grind the edge to an angle to reach in and properly shape the piece. Do not hesitate to do this if necessary—files are cheap, and the special file prepared for the job today will again prove useful on some future job. Plenty of files constitute the gunsmith's greatest asset.

The work with the mill file should bring the part to within one or two thousandths of final dimensions, after which it is finished to exact size with fine Swiss files of the required shape or size. Very small parts that cannot be readily held in a vise for finishing may sometimes be finished by laying them on the file and pushing the part against the teeth with the fingers. Another way is to soft solder the part to a piece of brass or steel large enough to be held in the vise; finish one side, melt off the solder, turn it over and solder the other side, and finish. When finally removed the solder that remains is readily polished off with fine emery cloth.

FILE SCULPTURE: This term has been aptly applied to the work of a few skilled artisans in the manufacture, entirely by the use of files, of various complicated small parts; and certainly there is no greater skill in all the field of mechanics, than was displayed by a few old timers, here and there, in the shaping of ornamental devices, hammers, cocks, frizzens, etc., as well as the even greater feats of cutting out entire breech portions entirely by hand. I have seen John Wright who has served his time with the finest gunmakers in England take a heavy block of tool steel, and with cold chisels, hacksaws, drills, and files *and no other tools,* shape it into a beautifully formed shotgun breech. The complicated inside cuts, and the wonderfully graceful curves, of the standing breech indicate the ultimate in skilled craftsmanship and natural ingenuity. The corks on many ancient weapons are still regarded with awe by collectors, who cannot but marvel at the unlimited patience with which the old-time gunsmith filed, day after day, week after week; until the finished gun in its beauty and dignity, embodied not only the soul of its maker, but the very spirit of the indomitable age in which he lived. And then, to have to compare this class of work with the cobbling of some of the so-called mechanics of today!

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But I am forgetting the die-sinkers; here is a trade which should have been classed with the fine arts. To watch a good die-sinker at work cannot but benefit any gunsmith, amateur or professional—and if you have in mind some little job of filing, like the making of a fancy shotgun hammer, of which you stand in awe, make it a point if possible to visit a shop where die-making is in progress and see some *real* filing done. You'll learn more in five minutes than you could acquire from a week of reading. You will see filing done in corners, angles and inside curves that you never dreamed a file could reach. You will see clean cut work turned out in places where the stroke of the file is so short you will wonder that it cuts at all.

In the shaping of hammers and other parts with curves difficult to reach, you will learn to appreciate the small Swiss files and rifflers; for no other tools will do the work that they do so easily, once you become acquainted with their possibilities. And one of the most useful of these is the American Swiss crossing file, in lengths from three to six inches. Having a nearly flat curve on one side and a deeper curve on the other, and tapering to a slightly rounded point, with hard, sharp teeth to the extreme tip, they will almost do the impossible, cleaning out curves and corners that could not otherwise be reached at all.

COLD CHISELS: The uses of cold chisels are often not appreciated by the gunsmith, despite the fact that lengthy practice is not essential to their use. Often a large amount of filing may be avoided by a little judicious chisel work, and chisels of any required shape and edge may be quickly forged out as needed. A quantity of high grade tool steel in 3/8, 1/4, and 1/2 inch hexagon bars will pay dividends when you learn to use chisels.

In making chisels, both ends should be forged. The butt end is hammered to a slight taper, and at the same time slightly upset and the edge rounded. The point is flattened and drawn to required shape, with considerable "cold forging" as the metal cools, to compact and strengthen the fibres. The shape is then trued up by filing or grinding, then both ends are hardened and tempered separately. First polish the end to be hardened with medium emery cloth. Heat to cherry red for about two inches, and dip the end for about 3/4 inch in oil to harden. Quickly polish the end with emery cloth wrapped over a file, and watch the colors run down from the hot spot back of point. When the butt end is blue, dip entire chisel in oil. Harden and temper the cutting edge or point in the same manner, drawing the temper at light purple or brown.

In using cold chisels always consider the size and character of the work, and avoid heavy chiseling where it is likely to spring or bend the metal. Hold the chisel in left hand, with palm cupped above the edge to deflect chips of metal and prevent their striking you in the face or eyes. When a considerable cut is to be made,

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start near the edge and work back, taking out a chip with each blow of the hammer. Learn to strike with the same force each time, and take the same depth of cut.

In selecting and sharpening your chisels, don't try to emulate the garage man who uses a chisel principally for cutting off bolts. Your chisels will be smaller, lighter, harder, and with decidedly more bevel than he uses. And you will not be limited as to shape—your chisels may be made any shape required for the job in hand. In grinding (which should be done the minute a chisel's edge is dulled), use a fine, fast emery or carborundum wheel, and very light pressure to avoid burning. Hold the chisel on the wheel only a second or two; dip it in water, and grind again, continuing until the edge is satisfactory.

Cold chisels are never sharpened on a stone; the slightly rough edge left by a fine grinding wheel is best for use on metal. If you have no grinder, it is permissible to touch up the edge on the coarse side of the carborundum stone, but frequent grinding of cold chisels is always necessary. When the grinding has shortened the point to the extent that the temper of the edge has changed, the chisel should be first annealed, then polished, re-tempered, and re-ground.

DRILLING: It would seem an easy matter to put a drill in the chuck, center it on the spot, and turn the crank. But there's more to drilling than this. The first essential is a good, properly ground drill; the second, an accurate center punch; the third a correct drill lubricant.

Metal that has been case hardened or tempered must either be spot annealed, as described elsewhere, or a spot must be ground off the surface so that the drill may take hold. When neither plan is available, coat the surface with melted beeswax or paraffin, work a small hole in the wax with the point of a scriber, and apply a drop of Spencer acid (See Chapter 20) or a solution of 1 part nitric acid and 4 parts water. When the strength of the acid is exhausted, apply more, and continue until it has "eaten" away the surface of the metal to a depth of 1/32 inch. Wash off with water, and center punch, and the drill should go in easily. Sometimes very hard steel can be drilled by a common twist drill hardened by heating to cherry red and cooling in mercury. This makes the point so brittle that great care is necessary to prevent chipping off—use light pressure, and run drill slowly. When drilling very hard steel, use pure turpentine instead of oil as a lubricant for the drill.

Take care of your drills and grind them as soon as they get dull. It is impossible to describe how to hold a drill and give it the peculiar twist required to correctly shape the point—visit a machine shop and watch them do it—then spoil a few old drills for practice. Best to have a good drill grinding attachment for your grinder—it will quickly pay dividends.

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Never put enough pressure on a drill to spring it; use plenty of good lubricant and if the point does not take hold it means that the drill needs sharpening. If a drill becomes bent, discard it at once, and save it for pins or something else. A sprung drill will enlarge and taper the hole, perhaps making it too large for the screw that it is intended to fit.

Marble's Nitro Solvent Oil makes a splendid lubricant for drilling small holes. Pure lard oil and kerosene is another good one; or the lard oil may be used straight. Turpentine and camphor, half and half, will enable you to drill glass without chipping.

REAMING OPERATIONS: Be sure your reamers are in good shape, correct size, and sharp. Unless you have considerable experience in grinding reamers, take them to a grinding shop when they need sharpening. When reaming it is important that the work be held rigid in the vise—any springiness may cause the reamer to "chatter" and make a rough cut.

A good strong die holder of the proper size makes the best handle

for large reamers. Never try to use the reamer in a brace, nor in a monkey wrench, as I have seen done; the tap wrench is fine for small reamers, and the die holder for the larger ones. Grasp the handle in both hands, and turn steadily with equal pressure on both ends. Use the soda water and oil mixture referred to in Chapter 31 as a lubricant, and use plenty of it. Remove reamer and wash out the chips at frequent intervals. Feed the reamer slowly, and if it sticks, do not try to force it, or you will break a blade; back up the cut slightly, and feed lightly.

TAPPING SCREW HOLES: The use of small screw thread taps is often a bugbear to the amateur mechanic, particularly when tapping shallow holes in tough steel. Some information on this subject is given in Chapter 29 in connection with the fitting of sights and scope bases, but a few suggestions of a general nature here may not be amiss.

Be sure your drill is the correct size for the tap—check up on the gauge, and check the drill size by trying it in the hole of the gauge. If the hole is shallow, bottom it out level, either with a wheel or inverted cone burr on a dental engine, or with a flat drill (See Chapter 4), or an end mill of the proper size. Always start the thread with a starting tap, that is with the end ground tapered; and as soon as the end of tap hits the bottom of hole, continue with a similar tap with less taper, finishing with one having no taper at all.

When tapping thick, tough stock, or when using rather small taps, the chips of metal cause the tap to stick at frequent intervals. Use plenty of oil, and when the tap sticks, never try to force it. Back it up a turn or two, then go forward again—slowly and gently. A tap broken off short in a hole is the best thing I know of to cuss about. Sometimes it can be drilled out with a dental burr, but

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likely as not it will prove necessary to heat the spot red-hot with an acetylene torch to anneal the tap—and this is not going to do the gun any good. After annealing, the broken tap can usually be drilled out.

Remember that taps are very hard, and hence easily broken. When you feel the tap springing ever so little, without turning in the hole—ease up! Something is wrong, and it may snap off in an instant. Back it up a bit, apply more oil, and go ahead.

The fact that a rifle receiver wall is hardened on both sides is often the unexpected cause of breaking both drills and taps. The annealing, or grinding off of the outer surface may leave the inside surface nearly as hard as it was before; and when the drill hits this hard surface in going through, it may snap like a toothpick. Slow up the drill when nearly through, and use plenty of oil. The same applies to the tap, only more so. Take your time when using small taps, and remember it's better to waste ten minutes doing the job than to break off the tap and waste a couple hours getting it out.

A FEW SHOP KINKS: To increase the size of a worn reamer, burnish the face of each of the teeth with a smoothly polished burnisher made from a three-square file. An increase of from two to ten thousandths is possible, after which the reamer may be carefully honed to size with a slip hone.

To make a tap or reamer cut larger than itself, pack twine or waste in one of the flutes, to crowd it over against the opposite side. In very large sizes, put a strip of tin on one side, and let it follow the tap or reamer blade around.

All lathe or other machine work calling for water cuts will be improved by using strong sal soda or soap water instead of plain water.

Babbitting bearings: Put a lump of rosin the size of a walnut in the babbitt, which will make it flow better and improve its quality. Rosin also prevents "blowing" when the bearing boxes are damp.

Kerosene is the best cutting lubricant for turning or drilling aluminum.

Preventing rust on tools or guns in storage: Use vaseline or a heavy acid free grease with a small quantity of powdered gum camphor added; melt the grease and camphor together over a water bath.

Preventing rust on polished steel stock, drill rod, etc. Polish the stock dry with very fine emery cloth, then wash with a solution of 1 pound copper sulphate in 3 pounds rainwater. This forms a rust proof copper coating on the steel.

Scale is easily removed from steel after welding or forging, also from castings, by pickling in water, 9 parts, sulphuric acid, 1 part.

Removing old bluing: Wash with pure hydrochloric acid, then rinse in clear water. It is necessary to polish parts with abrasives before rebluing, but this will greatly reduce the polishing necessary.

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Bluing steel parts without heat: Coat with pure nitric acid; wipe off acid with clean rag, apply linseed oil, then burnish lightly on a wire buffer.

To distinguish between iron and steel, file the surface bright and apply a drop of pure nitric acid. After a minute or two, wash off with water. On wrought iron the spot will be a pale ash gray, on steel a brownish black, and on cast-iron a deep black.

Case-hardening with kerosene: A quick and easy method for small hurry-up jobs. After polishing, rub the part thickly with ordinary laundry soap, then heat in charcoal fire to cherry red, and immediately plunge into kerosene. The parts are left white and clean by this method and free from scale.

Always maintain uniform speed when using twist drills; to make a drill cut faster, increase the feed but not the speed.

For a quick setting rust joint: 1 part powdered salammoniac, 2 parts sulphur, 80 parts fine iron filings, water to make a thin paste. Useful for setting screws to fill up old screw holes, etc., particularly when screw is loose in hole.

Metal to expand when cooling: Lead, 9 parts; antimony, 2 parts; bismuth, 1 part.

Moisture resisting glue: White flake glue, 1 pound; milk, 1 quart; soak over night, then cook same as water mixed glue, adding milk as needed to thin.

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CHAPTER 8

WOOD FOR GUNSTOCKS

EARLY American rifle makers and gunsmiths employed hard maple almost exclusively for their stocks and the use of this wood persisted through the flintlock and well into the percussion period. Although maple possesses many advantages for gun stocks, the exact reason for its selection, in view of the large supply of walnut then available, is unknown, but the numerous beautiful specimens of early American fire arms now remaining with us and the excellent appearance of their stocks after a hundred years or more of service would indicate the good judgment of their makers in the selection of the wood.

From the limited information available on the subject it appears that walnut was used for stocks in Europe almost from the beginning of fire arms, and walnut, both European and American, is today in almost universal use. Stocks have been made from other woods—beech, birch and oak stocks are not uncommon—but walnut is becoming the standard, and while its use may be in a measure due to custom and sentiment, yet its qualities are so well adapted to the purpose that probably no better all-round wood will ever be discovered.

MAPLE (*Acer Saccharinum*, also known as HARD MAPLE, ROCK MAPLE and SUGAR MAPLE.): This wood is a native of Eastern United States and Canada and its many desirable qualities will fully justify its use by those who prefer it to walnut. Its weight is similar—about 37 pounds per cubic foot when seasoned. It is often found with curly twisted grain, also in birds-eye maple. When first cut the wood is almost pure white and becomes somewhat rosy after seasoning. When thoroughly seasoned it is extremely hard and dulls tools very rapidly. It has great strength but is somewhat more brittle than walnut. Its white color of course necessitates the

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use of stains in finishing, but when properly applied to the right kind of maple very beautiful results are obtained. I have seen a stock of curly maple with a few birds-eyes scattered here and there, the beauty of which could not be surpassed by the finest imported walnut.

APPLE (*Pyrus Malus*): Occasionally one of the old school rifle-makers would employ this wood for a stock, with splendid results. Although the outer wood is nearly pure white when cut, the heart is a rich reddish-brown very hard and dense—the pores not being visible to the naked eye. So durable is Apple wood that it has been successfully used for cog-wheels in light machinery, and is largely used for tool handles, being nearly as satisfactory as ligum vitae for this purpose. It has also been suggested as a suitable wood for the heads of golf clubs. It should be seasoned for several years, and its use

requires sharp tools. Although I never made a stock from Apple wood, I would expect it to take the finest of checking, and would employ oil for finishing, same being thinned with turpentine to assure penetration.

CHERRY *(Prunus Avium)*. A well known wood, and one considerably used in earlier times, particularly by the backwoodsman building his own rifle. It was not the choice of the gunsmith as a rule, who preferred curly maple. Cherry, when first cut, is of a light red or pink, but darkens somewhat on exposure. The annular rings are very distinct, the pores very fine, but numerous, and medullary rays strongly marked. Due to its greater density of grain, greater weight, and greater strength, I consider Cherry superior to mahogany for stocks. It must be thoroughly seasoned, and only the heart wood should be used, as the sap is almost certain to become worm eaten in a few years. By using a little filler, a very fine oil finish can be obtained on Cherry. The weight ranges from 33 to 49 pounds per cubic foot.

ROSEWOOD *(Dalbergia nigra)*, Brazil: This wood is quite well known throughout America and Europe, but is less popular for furniture now than formerly. The grain is very firm, very hard and of close texture. It takes an exceedingly smooth surface and a high polish. Pores are irregular in size and position, varying in size and numbers in the different concentric growths. The color is a light red which, before finishing, fades on prolonged exposure to light. There are irregular belts of dark lines following the concentric growth, and the medullary rays are fine and numerous, often crossed at right angles by fine whitish lines, forming a beautiful and intricate network pattern. Quarter-sawing often brings out a beautiful ripple or "fiddle back" grain.

An excellent stock wood, although quite heavy (54 pounds per cubic foot) and usually difficult to obtain in sufficiendy large pieces. Should be oil finished, using light colored oil. Takes fine checking perfectly with sharp tools, and is one of the easiest woods to check, by reason of its density and hardness.

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ROSEWOOD *(Dalbergia latifolia)*, East Indian: Although well known in this country as a desirable furniture wood, it is seldom used for gunstocks, although occasionally a rosewood stock is found on a fine handmade shotgun. Its greatest drawback is the difficulty of obtaining it in pieces sufficiently large, as nearly all the supply is made up into veneer. Its color is variable, generally a rich light red streaked with a deep purplish black, and with varying golden yellow shades. It is dense and hard, with fine close grain, heavier than walnut and somewhat more brittle. Average weight 53 pounds per cubic foot. It takes a splendid polish with oil, which deepens the color and improves the appearance. Usually it is easy to check, being so hard and dense that there is little tendency for the tool to follow the grain. Sometimes, however, there will be a contrary hard and soft grain very difficult to handle even with the sharpest of tools.

MAHOGANY: There are so many varieties of this well known wood that one wonders why its use should be so largely confined to furniture. Mahogany is found in Africa, Central America, the West Indies, Cuba, Costa Rica, Guatemala, Honduras and many other parts of the world, and the different species vary so greatly in appearance and character that many of them would not be recognized as mahogany by the average person. "Spanish" mahogany comes from the Spanish possessions in the West Indies, and not, as many suppose, from Spain.

The varieties best known in this country are the Central American, West African, and Honduras. "Cherry" Mahogany is a term applied to any variety that is similar in color to our Cherry wood, and is not a distinct species.

The color varies from a light cherry to a deep reddish brown, although the color of most mahogany furniture is deepened with stains. Most of the wood used in furniture is straight grained, the grain being laid in alternate layers a half inch to an inch wide, each running in slightly different directions. This makes mahogany very difficult to work—roughens one streak while smoothing another.

Most mahogany has a rather open grain, is softer than walnut, and generally less desirable for gunstocks. The man who has a "hankering" for a fine mahogany stock may, if located near a dealer so that he can make his selection from a large stock of several varieties, succeed in finding a piece that will be the everlasting envy of all his shooting friends. For there is nothing in nature more beautiful than the indescribably intricate pattern of a fine African mahogany burl—and nothing much scarcer, either! So unless you are lucky, and just happen to run across such a piece, better stick to walnut—for the straight grained mahogany usually sold to furniture manufacturers would make a mighty cheap looking stock.

Personally I believe that mahogany, if used for a stock, belongs on the sample gun, or one intended for presentation, rather than for serious work. The wood is more brittle, and has not nearly

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the strength of walnut. It is much lighter in weight,—from 26 to 31 pounds per cubic foot—so that unless the stock is very large and thick, the gun will be decidedly muzzle heavy. The large pores do not adapt it for checking except by an expert, neither is the wood adapted to oil finishes. Filler is an absolute necessity, and either lacquer or dull rubbed varnish should be employed in preference to oil.

MYRTLE. At least one firm in the United States advertises Myrtle wood stock blanks, but I am of the opinion that the word is a misnomer. Boulger, in "Wood" (London, 1902), says "—a name not applied to any useful wood in the Northern Hemisphere." The Myrtle of this country is a small bush or shrub, although the name Myrtle is sometimes incorrectly applied to some varieties of Beech.

MYRTLE, BLACK *(Cargillia pentamera)*. This wood, a native of northeast Australia, is also known as "Grey Plum," and it, or some of the other varieties of that district should prove desirable for stock wood, and may be the wood offered in this country under the general name of Myrtle. Black Myrtle is reddish in color, close grained and tough, strong and durable, taking a high polish.

MYRTLE, DROOPING *(Eugenia Ventenatii)*. This also comes from Northeast Australia, where it is known as "Brush Cherry." It is heavier than walnut—47 to 57 pounds per cubic foot; it is light reddish or yellowish, not very attractive as to grain, but strong and elastic, stands seasoning without checking or cracking, works well, and takes a good polish. In Australia it is used for boomerangs, staves, oars, boat building, and tool handles.

MYRTLE, SCRUB *(Backhousia myrtilfolia)*. Another northeastern Australia variety, known also as Native Myrtle, Grey Myrtle, and Lancewood. Light yellow, often beautifully marked with dark brown, walnut colored stains, very hard and close grained, tough and durable. Seasons and works well. In common use in this country for bows, also extensively used for tool handles, mallets, etc. Should take checking well, and good finish.

BEECH *(Fagus sylvatica)*. This wood is light reddish brown in color, fine grain, small pores, with annular rings and medullary rays strongly marked. It should be sawn into boards or planks immediately after felling. Beech has been used in gunstocks because of its close grain and rich color, which darkens with oil rubbing, but its liability to attack by worms makes it somewhat undesirable. It takes checking well, and is very strong and elastic. This wood is found in Great Britain, Norway, and throughout central Europe to Spain; also in Asia Minor and Japan. The Asiatic varieties are lighter in color than the European, with more uniform color; are also somewhat softer and more easily worked.

BEECH, TASMANIAN, or EVERGREEN BEECH *(Fagus Cunninghamii)*. Also called Myrtle, and Nigger-head Beech. Native of Tasmania and Victoria. A rich brownish satiny wood, vary-

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ing from greyish brown to brown-pink. Cuts to smooth surface, and wears smooth. Very strong and close grained, with greater strength than the European beech. Alexander L. Howard, in "Timbers of the World" recommends it for felloes, staves, saddle trees and gunstocks. Quite possibly this is the "Myrtle" sold for stocks, as the description would indicate its desirability for that purpose, although I have never seen it used.

BEECH, AMERICAN *(Fagus ferruginea)*. A heavy, hard, very tough and strong wood, rather coarsely grained, warps in drying, but takes a very smooth beautiful polish. Color ranges from white to light brown. Used for plane-stocks, shoe lasts, tool handles and furniture. Should take checking well, and make a strong, durable stock, but would likely require staining.

WALNUT *(Juglans regia)*. Boulger states that the European walnut was originally a native of Northern China and Persia, having been introduced into Greece and Italy in the early times from Persia and from thence into other parts of Europe. The trees are

similar in size to our American walnut but the wood is considerably more varied in color and grain than that grown on this continent. European walnut includes several varieties, namely English, French, Circassian, Italian, Spanish, Turkish and perhaps some others. The general characteristics of all are quite similar so it is difficult to draw any definite distinction between them. Since all belong to the same order, their variations are only such as would be caused by the difference of soil and climate.

Most of the so-called Circassian walnut imported into this country in the form of gun stocks probably never saw the Circassian district. It makes little difference, however, as Circassian walnut is not necessarily better than any other walnut. This fact, however, is outstanding that a really fine piece of Circassian walnut will probably be of a higher grade than could be obtained in any other variety. Needless to say, the European gun makers have the available supply at their disposal and it is but natural that little of the first grade wood should be permitted to leave the country.

True Circassian walnut is characterized not by curly grain as many suppose but by sweeping dark lines deepening into black when finished and these lines may and often do assume fantastic patterns. Curly Circassian walnut is cut from burrs or crotches, the same as any other curly wood. That taken from the body of the tree is usually straight grained. When cut on the quarter, Circassian walnut, in fact almost all varieties of walnut, will show "watered" grain, also called "Fiddle-back" and "Tiger-tail." A straight grained stock of "fiddle-back" walnut of any variety is just about as beautiful a thing as one may expect to see. The fact that a number of very fine guns have been built with Circassian walnut stocks is leading to the rather common belief that Circassian walnut is essential to a fine gun. Nothing could be farther from the truth. Cir-

Upper blank is on Blazed Maple, furnished by Bell, Lewistown, Penna., and is a splendid wood for stocks but this particular blank is incorrectly cut for best design at grip and comb. Center is a beautifully colored Circassian Walnut blank, ranging from reddish orange to black,—an unusual combination of varigated colors and figure, and a good example of high grade American Walnut taken out of upper part of the stump. Lower blank is an example of "fiddleback" Very beautiful wood. Nearly colored and figured above ground.

cassian walnut is good if it is good and a poor piece of it is worthless.

One thing I have noted in the past is that much of the Circassian walnut imported into the United States is very light colored sapwood with little figure and some of it is suffering badly from dry rot. The only way to assure quality in the purchase of foreign walnut is to go to the European dealers and inspect the wood at first hand before buying. There are a few dealers who have advertised gun stock blanks in this country who have supplied very nice wood, but "buying a pig in a poke" is always an uncertain proposition.

ENGLISH WALNUT. High grade English walnut is as a rule finer grained and somewhat harder than most American walnut; also somewhat lighter in color. With proper selection it makes very beautiful stocks and it, together with French walnut, is the preferred material of some of the best English gun makers. Considerable quantities of English walnut are also imported into this country for cabinet and interior panel work.

FRENCH WALNUT is usually straight grained and lighter in color than English walnut. The French walnut I have seen is apparently somewhat softer than the English, although the two woods are very similar.

ITALIAN WALNUT is supposed to be dark in color and well figured. I have never had the opportunity of studying any that I knew positively to be Italian so am not in position to make any assertions but many gun stocks I have examined which were sold by the makers as Italian walnut have been very light in color and of very poor grain, with scarcely more figure than white pine.

SPANISH WALNUT. England imports a moderate quantity of walnut from Spain and the general characteristics of it are so similar to French walnut that one might be mistaken for the other.

TURKISH WALNUT. This is also quite similar to French walnut but is usually darker with a larger proportion of figured wood.

AFRICAN WALNUT *(Lovea Klaineana)*. This wood more nearly resembles African mahogany in grain, finish and weight than it resembles walnut and is not a true walnut at all although well adapted to gun stocks and the other uses to which walnut is put. In color it is similar to much of the European walnut but is somewhat lighter in weight—about 30 pounds to the cubic foot. Occasionally yellowish brown golden tints are found which give quite a unique effect. This wood is not available in the American market to my knowledge.

BLACK WALNUT *(Juglans nigra)*. This wood, which is the only real American walnut, is much better than most people realize. From it is manufactured most of the so-called French, Italian, English and Circassian walnut furniture sold in our stores. One who knows American walnut can give the lie to most claims of the average furniture salesman who glibly calls a panel "Circassian"

if it shows a great deal of burl and French and Italian walnut if it happens to be light in color. The same salesman will also tell you that the piece you are looking at is solid walnut, even though the grain shows identical on top, edges and end proving it to be veneered. Such a great quantity of American walnut is now made into veneer and thus used in furniture that the supply is being rapidly decreased. Year after year we somehow find enough for our use despite a common belief that the supply is nearing an end. The increasing scarcity of the better grades, however, is evidenced by one fact which I have noted. Rifle stocks made by the government some fifteen years ago are much harder and closer grained wood than those turned out more recently. This is particularly noticeable on the Springfield Sporters sold by the Director of Civilian Marksmanship. Every one of these I have inspected and handled has been of very soft wood and so very porous that the linseed oil in which they are dipped has turned them almost black. Apparently, however, they are sufficiently strong, and are straight grained; but their general character seems to indicate a shortage of the fine old hard wood used in the Krags and even the Springfields before the war.

The walnut of North America all belongs to the same family and varies only with the soil and climatic conditions just as European walnut does. The finest grained, hardest and best figured wood is produced in the rough or mountainous country where the soil is somewhat rocky, while the porous wood comes from the low or swampy districts and is really unfit for gun stocks.

I believe it is safe to assert that there is a greater proportion of good figured American walnut available than there is of any of the

European varieties. The color is generally darker and richer and by careful selection the most beautiful stocks can be procured at a fraction of the cost of imported wood of equal grade.

In some of the southern states, particularly Texas, the walnut produced is very close grained with fine pores and is marked with long dark streaks not unlike Circassian walnut. I have known of this wood being sold as Circassian in more than one instance. It has, however, more of a reddish cast and is softer, yet it ranks high as a wood for stocks by reason of its density and the splendid finish which it takes.

One of the largest manufacturers of walnut veneer tells me that the very finest, most beautifully grained curly walnut in North America comes from Missouri, Kansas, and Indiana, in the order named; and the poorest, from the standpoint of density, figure and strength, comes from Iowa. Some very finely figured wood also comes from the semi-mountainous districts in southeastern Oklahoma, as well as from many eastern states.

American walnut will average between 37 and 38 pounds, which weight produces a stock which balances about right with our modern

Upper is a very fine blank of clouded Circassian Walnut. Center is one of Mitchell Bosly's best imported blanks and is about as well figured as will be found today, not a flaw in the grain and very hard and dense. Lower blank is a piece of good old American Walnut with "fiddleback" grain and nothing more beautiful ever comes from Europe either

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fire arms, particularly rifles. The Southern wood is somewhat lighter than that grown in the Northern states. Almost all American walnut will show "fiddle-back" when quarter sawed with the exception of the Texas walnut previously referred to. In selecting wood for a high grade stock there is a natural tendency to choose a quarter sawed plank in order to get this effect. Theoretically this is the wrong thing to do if maximum strength is sought. Figure 38A shows a sectional view of a walnut log divided into quarters. Two upper quarters are quarter sawed while the lower half is "board" sawed. Note that the quarter sawed planks have the edge grain presented on the flat surface while the others have edge grain on the

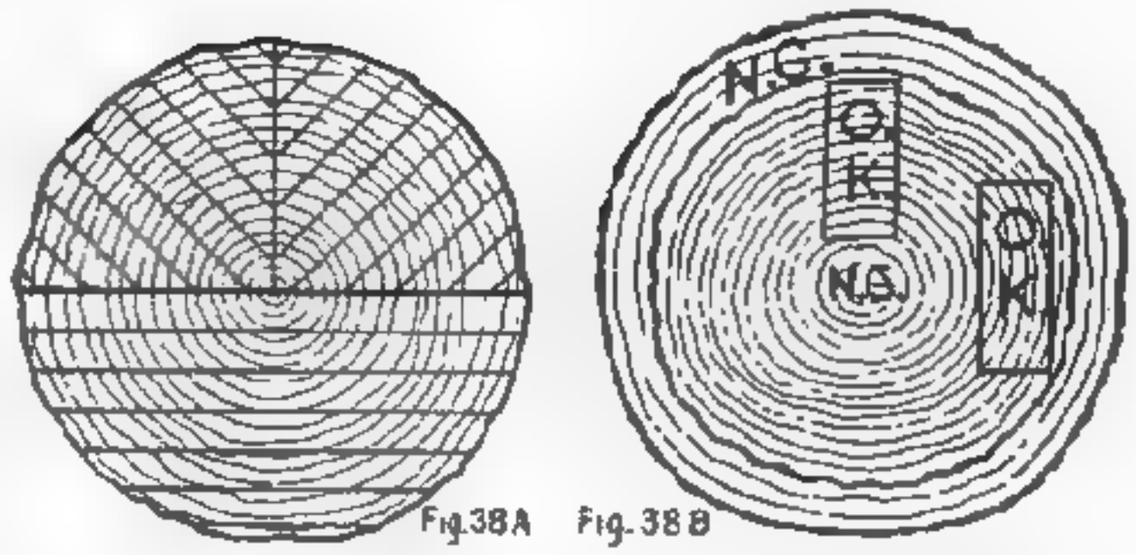

Fig. 38A Fig. 38B

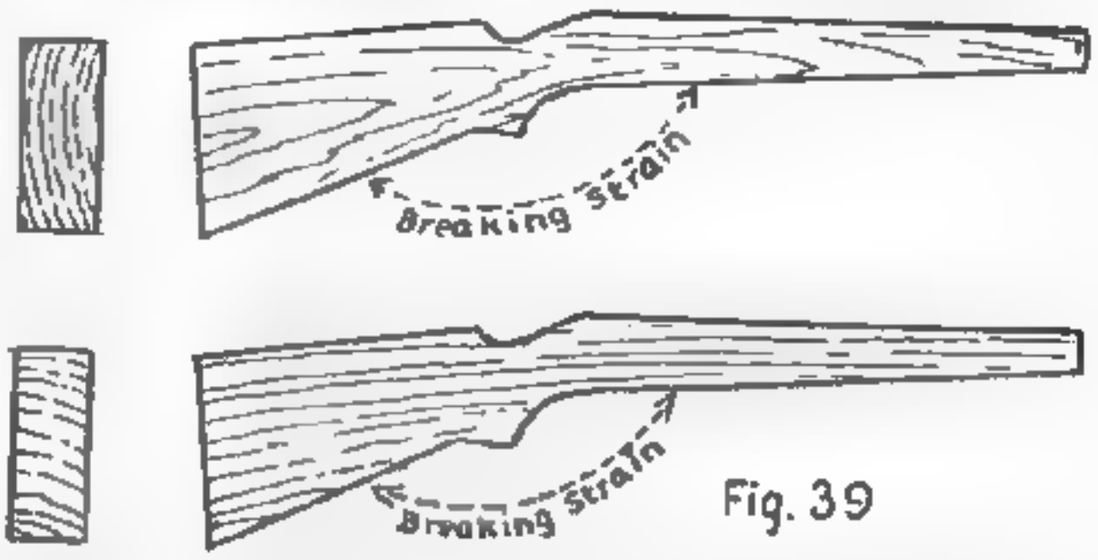

Fig. 39

edge with the layer caused by the annual ring formation showing on the flat sides. Edge grain as presented in the quarter sawed plank is stronger if the strain is brought to bear against the flat sides. However, since the strain on a stock usually comes in the direction of the bend at the grip, it is found that the "board" sawed lumber is better adapted to resist such strain. (See figure 39.) But, if one

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is careful in his selection he may choose quarter sawed walnut for his stock with most pleasing results and without any danger of breaking, for good walnut possesses an ample margin of strength, particularly if the stock pattern is properly laid out on the wood with due regard for direction of grain.

Figure 40 shows the ideal selection of a piece of walnut for a stock blank and the proper method of laying out the pattern. It is not at all unusual that a piece can be found curly at one end, the grain gradually straightening out but with a slight bend which can be worked into the grip portion so as to get the straight grain in the forend, grain curving with the grip and with plenty of figure in the butt where wanted.

Your choice, however, may be in favor of a piece of quarter sawed wood with the grain running practically straight. In such case it is

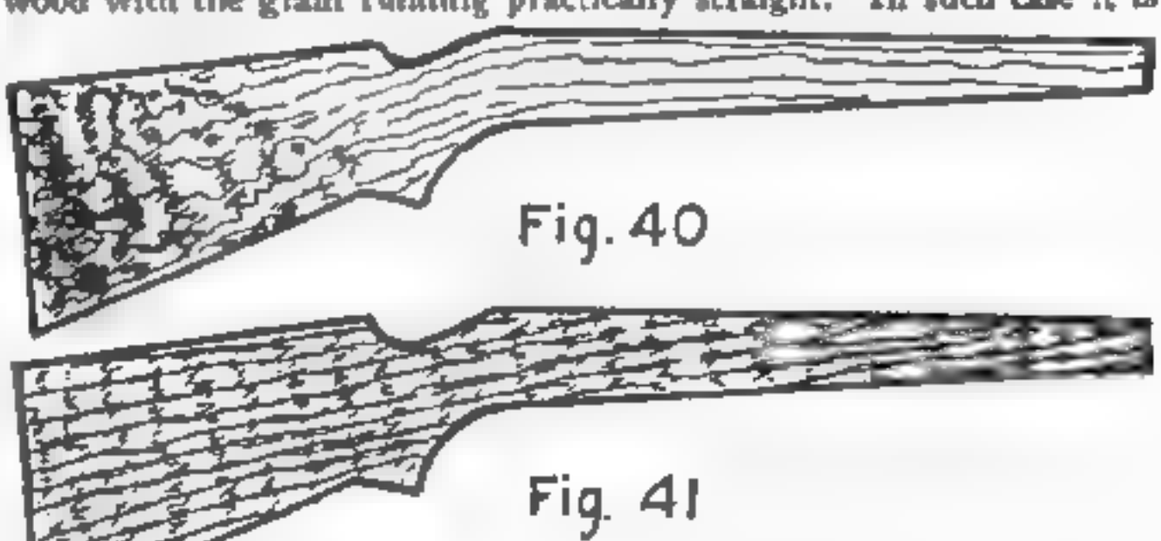

Fig. 40

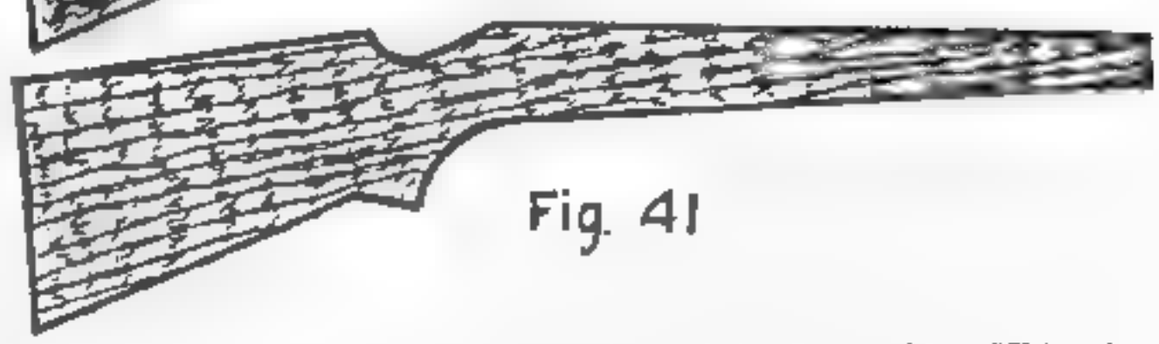

Fig. 41

better to lay out the pattern as indicated in figure 41. This gives the grain running up toward the forend which is not objectionable as it renders quite easy the inletting of the barrel, permitting chisel work mainly in one direction.

Figure 42 shows the right and wrong way of laying out a butt stock for shotgun or two-piece rifle stock. When the grain parallels the grip and bottom line of stock rather than the top line, the grip is greatly strengthened, and the danger of splitting off the toe (a very common accident) is eliminated.

The usual oil treatment provided for high grade stocks darkens the

wood considerably and in unskillful hands may result in hiding much of the beauty of the grain. For this reason it is well to select wood that is not extremely dark in color with due care to avoid sapwood. Another thing to be avoided is that variety of walnut sometimes termed gray walnut by the trade, which usually runs to

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the grayish purple tints and which is very soft with large open pores. In the rough plank this wood often seems more attractive than the lighter colors but it soaks such a quantity of oil that it becomes almost black and the finishing process is needlessly prolonged. Moreover this wood does not work well under checking tools, fuzzing up badly under the cutters so that it is almost impossible to sharpen and smooth up the diamonds in the proper manner and this is increased by the repeated application of oil necessary to finally secure a finish. Often the lightest of American walnut (providing it is not sapwood) will finish up sufficiently dark to make a truly beautiful stock.

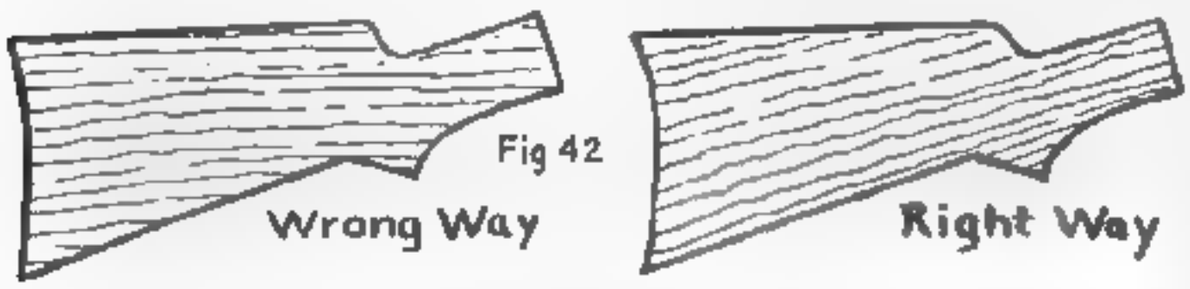

Fig 42

From the foregoing remarks the reader will probably gather that I am somewhat partial to American walnut as compared to the foreign woods. The fact is, I am partial to the wood which is strongest, soundest and most beautifully grained regardless of whether it grew in the Catskills or the Himalayas. This thing of specifying foreign walnut because it is foreign and not because it is good is all bunk. Some of the most beautiful stocks ever produced have been made of American walnut and some of the poorest, both as to design and appearance, have been of European walnut. This is not a general condemnation of the latter, however, but refers particularly to the lack of knowledge of what one is getting when he orders a foreign product. I have a Circassian walnut stock blank that is unusually dark in color and the most beautifully figured piece of wood I have ever seen anywhere. I have been offered $50 for this piece in the rough blank and was not in the least tempted. I have another piece of American walnut of equally fine finish and which from my own view point is equally valuable although it would not bring as much if offered for sale. The main object in deciding in favor of American walnut is that if it cannot be inspected personally when bought it can at least be purchased from a firm in this country to whom it can be returned if unsatisfactory.

The success or failure of any stock depends quite as much on the seasoning of the wood as upon its other qualities. The demand for walnut today is such that dealers cannot afford to keep their stock in the log for five or six years as required for best results. Green walnut contains a sap which if not thoroughly removed will cause excessive warping and cracking. Prolonged air seasoning under shelter destroys the effect of this sap. Some authorities claim that the logs should be soaked in water for the first few weeks after cutting, to soak out as much of the sap as possible. At all events the wood should be seasoned for at least one year and preferably two years in the log and from two to four years after the planks are sawed, and this treatment should then be followed by steaming in the steam kiln and drying in the dry kiln. The usual kiln drying time is 30 days but if I want to be certain of the quality of the stock blank I send the wood through the kiln a second time, or a total of 60 days. A peculiarity of walnut which renders it particularly valuable for gun stocks is that once properly seasoned it is virtually immune from any warping, either from immersion in water or by exposure to dampness or rain.

All over this country there are small patches of walnut timber as well as others not so small; and fortunate indeed is the fellow who has a few fine old walnut trees on his place if he happens to be a dyed in the wool gun-crank. He need not worry about material for the stock he hopes to make some day—for Europe never produced finer wood then the best of our American walnut.

The man who plans ahead to get out some native walnut for stocks should cut his trees, if possible, five years before he expects to use them. Cut with a short stump, or better yet, grub them out well down into the roots. Cut off the branches and let the log lay in the weather for two years, or possibly three. Then cut off the roots at about the ground level, and store the log in the open air but under shelter for another year. It should then be quarter-sawed and cut into planks three inches thick, to allow for further shrinkage. Stack these planks in the weather for three months, then under cover for the balance of the year, when they may be planed and sawed up into stock blanks, which should then be kiln-dried, or else store them inside in a warm dry place—close up under the roof of a barn during a hot summer will bake out any remaining moisture.

When you have an entire log to select from, there's always a temptation to cut your stock from the extreme butt, where the roots branch out; for here you get the most wonderful figure and coloring. But DON'T. Too much of a good thing is objectionable—and this wood will never get through warping this way and that; it will never seem to become thoroughly dry; and there is every likelihood that the stock may split any time it takes a notion.

Just above the ground line, or near a crotch where large branches occur, is the best place to get fancy stocks from a log. Figure 38B shows the portions of the log from which the soundest and strongest wood may be obtained.

With the supply diminishing and the demand increasing, it would seem that a vigorous program for the planting of walnut trees in localities where they will produce the finest wood, should be included in a National plan of reforestation.

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Chapter 9

STOCK DESIGN

THE earliest gun stock was merely a handle by which the piece could be held, after a fashion. Later, as it was learned that the best way to fire a gun was from the shoulder, the butt stock was developed somewhat along the lines seen today. On early matchlocks and wheel locks the stock was very thick—sometimes two or two and one half inches, and was usually fluted and heavily carved on the sides. Guns of this type were exceedingly heavy and ungainly, and little adapted to the use of early American hunters; consequently, when the Pennsylvania gunsmiths, to meet the requirements of the new country, developed that most famous of all arms, the Kentucky Rifle, they went to the other extreme, making their stocks very small and very thin, often—in fact, usually—with what is now considered excessive drop.

In appearance alone, the lines of the Kentucky Rifle left little to be desired; they were very graceful, with smooth, flowing lines, and possessed a "snap" wholly in keeping with the spirit of the pioneers who used them. Their small size, however, was just as much a mistake then as it would be today. True, the very heavy barrel absorbed most of what little recoil there was from the relatively light powder charge; yet the stocks, particularly the grip, had not sufficient strength to withstand the rigors of hard service—in support of which we have the fact that in the specimens available today as relics, *nearly every one* shows a crack in the grip, usually on the right side just back of the lock recess. Some of these have been repaired with screws or by winding with wire, while others were not repaired at all. It is scarcely conceivable that these fractures were caused by the recoil—more likely they were the result of dropping the butt on the ground. The fact remains that a rifle should be capable of withstanding any normal strain to which it may be put in its regular line of service.

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Most of the Kentucky Rifles also had excessive drop, and very thin combs. The former was perhaps permissible owing to the light recoil, but the thin comb has always been a mystery to me. Apparently the early rifleman liked to shoot with his "head up and tail over the dashboard" and a diet of corn pone and venison must have made them a heap fuller in the face than most of us today. Some of these old rifles had cheek pieces, usually very small in size, and located too low on the stock to be of much use. The butt plate was four or four and a half inches long, and a deep crescent in shape—another feature possible by reason of the light recoil. It is a notable fact, however, that the heavier European smoothbores of that period, using large balls and tremendous powder charges had wide, heavy butts, the plates nearly or quite straight—more along

the lines of our present shotgun butt.

Following the Kentuckys came the army muskets and carbines with larger, more comfortable, more sensible stocks—developed as a result of the heavier charges they used. The under edge of the stock, which was usually square in the Kentuckys, was now rounded; butt plates became larger and straighter, with the sharp corners rounded off.

The Henrys, Winchesters, and other factory made arms then came out with stocks somewhat of a compromise between the two. The grip was larger; the stock was considerably thicker, but, instead of the more sensible military butt plate, they used a crescent shape similar to the early muzzle loaders. At this point firearms designers made their first great mistake, in the development of the two-piece stock; yet it was not so great a mistake as it is today, by reason of the rather light loads to which the early repeaters were adapted. Marksmanship training, as the term is known today, was then unknown. Shooters doubtless had little idea of what their rifles were really capable in the way of accuracy—they gauged it by the phenomenal lucky shot instead of on a basis of steady performance, just as some shooters still do.

Somehow, I am unable to enthuse very much at the recital by some old timer of what wonderful shooting he used to do with his old rifle. I am reminded of an incident related by one of our local liars, concerning a shot he made when a mere lad (What a pity he was permitted to outgrow such proficiency!). It seems that his dad "kept store" in a small settlement in one of the northern states, doing a considerable trading business with the hunters and trappers of the district. As he tells the story:

"One old feller kind o' took a likin' to me—I was just a kid hangin' round the store—an' I was allus beggin him to lemme try his rifle. One day he was in an' he pointed t'ward sump'n shiny settin' on a stump off a piece, and sez t' me, 'Son, kin you see that?'—an' I sez 'Yep, jest kin see her—she's a gallon syrup bucket.' 'Well,' sez, he, 'Ef you kin hit 'er in three shots the rifle's yourn—pervidin'

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yore pappy let you hev it.' Well sir, I picked up thet ol' rifle—bigger'n I was—could jest barely heft it—an' drawed down on that bucket, an' let drive—DANGed ef I didn't knock 'er off the first pop! Well sir, Y'outa saw that ol' boy's eyes stick out! He paced it of jest a quarter of a mile exactly from where I stood to the stump—an' he gimme the rifle, too, an' I had her fer years! Aw, I was allus a good shot—come natcherl to me—my daddy, he was one o' the best shots in the country in his day—an' his daddy b'fore him. Why I've seen him stand off sixty paces an—"

At this point I impolitely interrupted to inquire as to the make, model and calibre of the rifle with which the syrup bucket was shot. He didn't remember, but his studied answers to leading questions seemed to indicate a '73 model Winchester; and he was sure it was a "thirty eight"—so I assumed it was a .38-40, black powder cartridge. Now, at 600 yards, the 1/20 inch blade of a Springfield just about covers a 20 inch bull; and I couldn't help wondering how much of an eight inch syrup bucket the big coarse hunting sight of that '73 Winchester would hide at 440 yards, assuming the shooter could see the bucket at all at that distance. I wondered also how an untutored lad of his years could have learned enough of the trajectory of that rainbow load to hold over sufficiently for a hit at that range, and how he would know where in time the bucket was while holding over. But at the very first question he cut me off with "Aw, hell, sonny—you young bucks today dono what shootin' is—we knowed how to shoot in them days—had to." So what's the use!

But we were on the subject of stock design, or at least approaching it. Apparently the factories, until a very few years ago, thought that the only purpose of the comb was that it provided a means of reducing the stock to grip diameter at that point. Combs were whittled down until they served no useful purpose whatever, and might better have been omitted—in fact, the comb is omitted on the British Lee Enfield, and on our own Model of 1917—and might just as well be on our Springfield service stock.

A few years back the pistol grip was practically unknown on a rifle, but was invariably found on all American shotguns—even the cheapest of them—and is yet. Gradually, however, we have learned that a pistol grip is a highly desirable thing on a rifle, and not so essential on the scatter-gun—particularly the type that is merely a wart located midway between the trigger and the toe of buttplate. Many of our best hand made double guns, and practically all our trapguns are today made with straight grips; while it is the almost invariable rule that the properly made rifle stock shall have a full, sharply curved grip located close behind the trigger guard.

The modern, properly designed rifle stock is a thing of beauty and grace and symmetry of lines; and its beauty is only equalled by the ease and comfort with which it is handled, particularly if built to

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order, to fit the shooter. Yet—and here's where I get scalped—the stock has not yet been built which really conforms to the physical characteristics of the human hand; and probably it never will be built—at least not unless and until our firearms are completely redesigned, which seems doubtful. The reason for this may be understood from Figure 43. By closing the hand, as in grasping the grip of a rifle stock, it will be observed that the lower joint of the fore-

Fig. 43 A Fig. 43 B

finger is in prolongation of the forearm (a, Fig. 43), and not at a forty-five degree angle with same, which position it is forced to assume in grasping any stock (b, Fig. 43). The exception to this is the grip of almost any automatic pistol. Here the hand is in a natural, comfortable position, the forefinger in the same horizontal

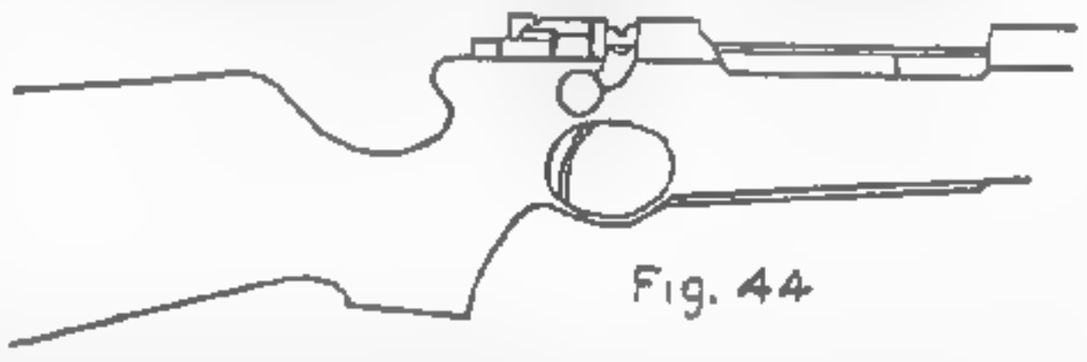

Fig. 44

plane as the trigger—not reaching down to it from above as when shooting a rifle, shotgun or revolver.

From a strictly utilitarian standpoint, then, our ideal stock should assume something like the shape shown at Figure 44, giving a grip similar to that of the automatic pistol. With present actions this is not possible; and if it were, we should soon tire of it, by reason of the ungraceful lines of such a stock. A gun—any gun—should

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appeal to the eye quite as much as to the hands that hold it—else why do we spend our money for fine finish and decoration?

Evidently, then, we must effect a happy compromise so that our stock, while following to a degree the conventional lines we have come to accept as standard, yet is so dimensioned as to provide maximum quickness of aim, and comfort in holding

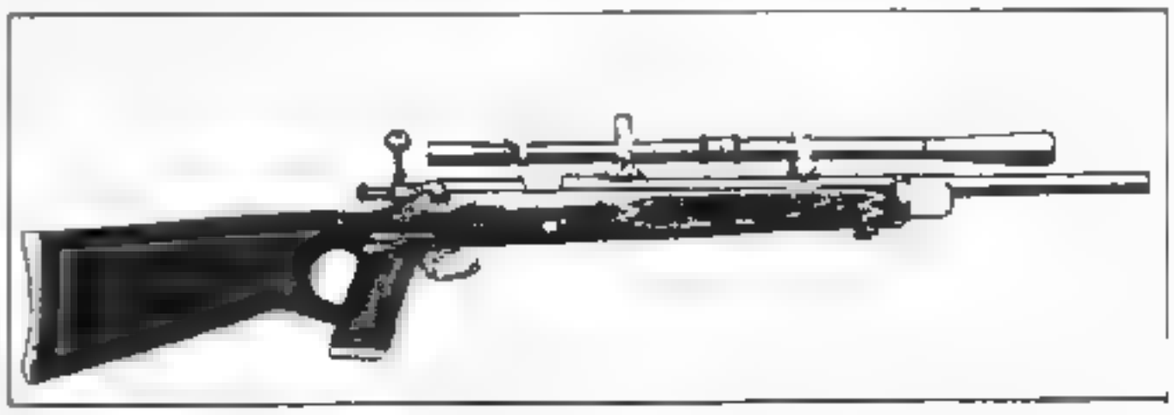

Fig 45

Figure 45 shows a stock illustrated a year or so ago in the American Rifleman—the work of a man trying to attain his ideal of practicability. I have no doubt this stock was far more comfortable and more easily held than any of our old stand-bys; yet, without knowing the owner, I'd be willing to bet my shirt he has before now discarded the idea in favor of a more conservative design. For deeply rooted in the heart of every shooter there is a secret admiration, a real affection, for a gun that *looks* like a gun; the familiar lines of old favorites that have been our companions in field and forest will not easily be supplanted by new and unfamiliar shapes, albeit they might prove thoroughly practical.

And, happy to relate, it is wholly possible to design our stock along conventional lines, yet modify dimensions in a manner to improve the handling and the beauty of the arm many fold. It is surprising what a difference little things make. An eighth of an inch in thickness or height of comb—a bit of castoff at the butt—a slight change in pitch—a different curve in the grip—these are some of the points that make or mar a stock. One may have two stocks that to all appearances are identical in size and shape; yet slight differences not readily discernible will cause one to handle perfectly while the other feels slow and clumsy.

STOCK NOMENCLATURE: Before going further into a discussion of these points, study Figure 46 if not already familiar with the nomenclature of a modern sporting stock. "A" is the forend, or forestock; "FT" is the forend tip; "G" is the grip, or as the English stockers call it, the "hand;" "FG" is the pistol grip; "CO" is the comb—and the low upper surface of grip just ahead of comb is sometimes spoken of as the "hand hole;" "C" is the cheek piece; "B" is the butt; "H" is the heel, and "T" the toe of butt.

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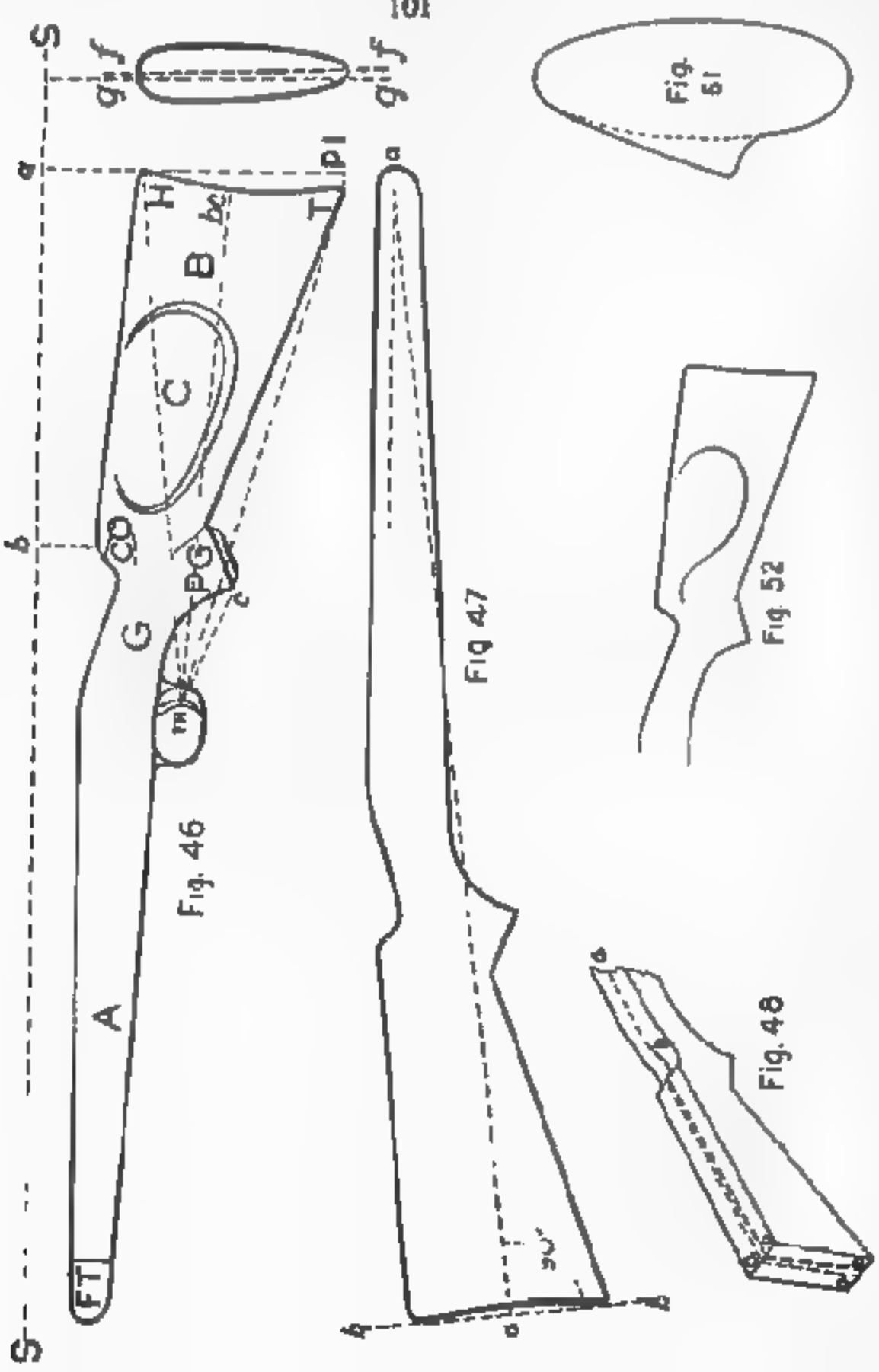

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The line "S-S" represents the line of sights when set for the range used most—usually 100 yards; from this line all drop measurements are made while all length measurements of butt stock and forend are made from center of trigger, "c." Thus, the length of stock usually refers to distance from center of forward surface of trigger to center of outer surface of buttplate, "c-c," although this may differ from the measurements to heel and toe, "c-H" and "c-T." Length of pistol grip is usually measured from center of front surface of trigger to forward edge of grip cap "c-c," and is of far less importance than is generally supposed; the curve of the grip, its thickness, its cross-section, and last and most important, its height with relation to the bottom line of stock, have far more to do with the feel and handling of the gun than this distance from trigger. This will be further explained later on in this chapter.

PITCH: The line H-PI is at right angles to the line of sight, and the distance from PI to the toe of butt, T, determines the "pitch" of the stock, if any. Pitch means the distance of the front sight from the perpendicular, when both heel and toe of butt are in a horizontal plane, i.e., resting on the floor. If a stock has too much pitch, or as some say, if the toe is too short, the heel may strike under the shoulder as the gun is brought to the firing position, delaying a quick shot. If it has too little pitch, or none at all (as when the buttplate forms a right angle with line of sight) there is a tendency of the butt to slip down on the shoulder, especially when shooting prone. Moreover, shotgun shooters and some rifle shooters also, claim that lack of pitch, or lengthening the toe, makes a gun shoot higher; and by this they mean that the bullet or shot charge actually leaves the gun at a higher angle with relation to the line of aim!

I cannot concur in this belief. I see no reason why the angle of departure would be altered the least bit regardless of how the butt might be shaped. This leaves us facing the alternative theory that with a long toe on our stock the recoil throws the muzzle high, causing us to shoot higher—I can't believe this either, for the simple reason that electric spark photographs of bullets and shot charges in flight invariably prove that said bullet or shot charge is well out of the muzzle and on its way *before the muzzle has started to rise from the recoil.*

In seeking the cause, therefore, of this almost universally acknowledged fact that the long toe actually does cause one to shoot higher, I have come to this conclusion—that hard pressure of such a stock against the shoulder causes it to slip down, just as the beveled latch of a door slides in when the door is pushed shut; and that, since 99 per cent. of shooters "buck" their shots, i. e., increase the pressure of the shoulder while pulling the trigger, this bucking causes a slight, and entirely unnoticed elevation of the muzzle a fraction of an instant *before* the discharge takes place—and naturally the shot flies

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high. I may be right or I may be wrong—am plumb willing to be shown the error of my ways; but it will take a lot of argument, and a lot of proof, to convince me that changing the pitch of any stock causes the least change in the relation of the bore to the line of sight—and that is what determines where the gun is shooting.

I have said that 99 per cent. of shooters buck their shots. Of the other one per cent. who don't, those who are riflemen know enough about stocks as a rule to have a pitch that keeps the stock in place on the shoulder; and those who are shotgun users are usually able to do pretty good shooting with anything that burns powder! But this argument is beside the question. Shooters have varying opinions as to the right pitch for rifle stocks, and many shotgun users prefer no pitch, or at least very little. The thing for a man to use is what he can use best—what he believes in—for confidence plays a mighty big part in the shooting game. Townsend Whelen prefers about a 3 inch pitch on his rifle, and this is the choice of many other expert target shooters and hunters. E. C. Crossman allows he wants from 4 to 5 inches, and for offhand shooting with a hunting arm this amount of pitch handles better for me. But on several rifles of my own that I have stocked for offhand shooting, I have no idea what the pitch is, having never measured it. My own rule is to cut the butt so that it forms a right angle with a line drawn from center of butt to a point in the forend tip level with the bottom of the barrel channel; in other words, making the butt, (b-b, Figure 47) at right angles with the center of form of the entire stock. This

gives me a definite rule to apply on my own stocks, as on bolt action rifles I want the forend tip about 18 inches from the trigger; others prefer a shorter forend, however, so the rule cannot be made universal.

When a man specifies the amount of pitch he wants on a stock, I make it as he wants it. When he leaves it up to me to fit him, I usually follow my own rule, carrying a line from center of butt to a point on bottom of barrel 18 inches ahead of the trigger and cutting the butt at right angles to it, and he usually remarks that the pitch seems to be just right. A stock so made will deliver the recoil very nearly through its center of form, and will cling to the shoulder in any of the shooting positions like a poor relative during a hard winter.

CAST OFF: Going back to Figure 46, the small "head-on" view of the butt illustrates what is meant by "cast off" in a stock. The line g-g is in prolongation with the center of the bore—in other words, the original center line of the stock. The buttplate has been shifted to the right a trifle so that its center comes on the line f-f. The stock is therefore cast off, or bent to the right a distance equal to that between these two lines. This slight bend is of course unnoticeable when the stock is viewed from the side; and one must look closely to see it from a top view. But it is there just the same.

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and while some deny the value of castoff and will have none of it, I find, in common with many others, that it speeds up my aim considerably. Castoff is not necessitated by either a thick or a thin comb—in fact, comb thickness has nothing to do with it, and neither has a cheek piece, contrary to common belief. But take a stock without castoff which fits you fairly well; bring it up so that you glance quickly through the aperture of the rear sight; and you are quite likely to observe that the front sight is off to the left of where it ought to be, as much as a half inch or so, and a perceptable fraction of time is required to give the slight twist to the neck that brings it into line. Therefore, moving the butt a trifle (say 1/4 inch) to the right, amounts to moving the front sight about twice that distance to the right, so that as you look through the aperture it is practically centered instantly. All this explanation presupposes the shooter is right handed—a left handed shooter would naturally reverse proceedings, making his stock bend to the left—"cast on", as it is usually called.

Castoff may be from 1/8 to 1/2 inch according to the shooter's build and method of aiming. Usually it is well to have a little more castoff at toe than at heel, since the hollow in the shoulder where the butt should rest slopes outward a trifle on most people. My own castoff dimensions are 1/4 inch at heel and 3/8 inch at toe. The bend should start just back of the trigger and run in a straight line to the butt. Figure 48 shows the stock blank laid out for a cast off stock, the line a-a-a being the original center line, and b-b-b the new center to which the stocker will work in shaping up the butt.

CHEEK PIECES: Next we come to the cheek piece, if one is to be used. I prefer, and have used for years a cheek piece of the pattern designed and recommended by Whelen, except that I like it set a trifle higher on the stock, its upper outline blending into very nearly the upper edge of the stock. Figure 49 shows the two types, A being the cheek piece preferred by Whelen and B, the one on my own favorite sporter. The distinction is largely theoretical, and the whole question is pretty much a matter of personal preference.

The cheek piece must be thinner at its forward end that at the rear, (See Figure 50) otherwise you will take severe punishment from recoil. When properly sloped forward, however, the recoil throws the pressure slightly away from the face, making the stock both safe and comfortable to shoot, and permitting a slightly thicker and more snugly fitting comb. Figure 51 is a cross section of a stock with well designed cheek piece—note that it forms a straight line from top to bottom edge, and is not hollowed or rounded. It may also be perfectly straight from its front to its rear end, although I prefer it very slightly hollowed in this direction. Thus shaped, the face finds exactly the same position every time, while with a convex cheek piece you will find yourself shifting about somewhat from shot to shot.

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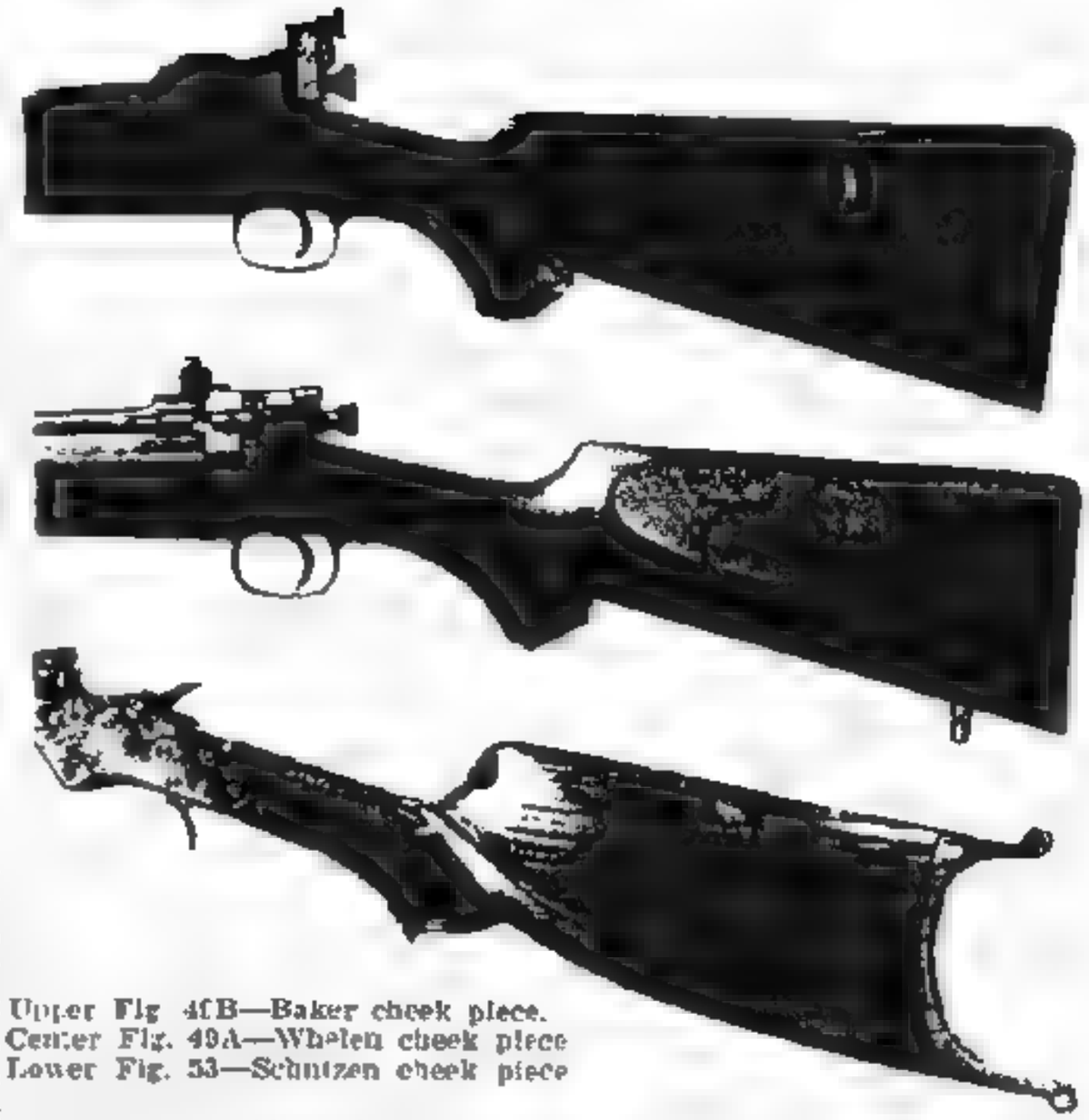
Referring again to Figure 51 note that the cheek piece *does not* add any thickness to the comb or upper edge of stock; the thickness starts increasing, of course, immediately below this edge, and continues to the bottom edge of cheek piece. The cheek piece is not



Upper Fig 48B—Baker cheek piece.
Center Fig. 49A—Whelen cheek piece
Lower Fig. 53—Schnitzen cheek piece

necessary to add comb thickness—that is not what it is for. You can make your comb as thick as you like—even the very thick combs on some Parker shotgun stocks are not unpleasing. But take up a gun without cheek piece, and with a comb that fits you perfectly, just throwing you into the line of sight when face snuggles the stock. Now you will find that you can slip your forefinger between the stock and lower part of the jaw—in short the face is supported by the stock at one point only slightly below the cheekbone. Now lower the gun and bring it up again, so as to bear the whole side of face against the stock. Now the eye is not looking through the sight line, but a half inch or so to the left of it. Shooters accustomed

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to shooting a stock without a cheek piece have developed an instinctive habit of cocking the head slightly to the right—and they do this *irrespective of the thickness of the comb*. The cheek piece merely provides a positive and controlled method of canting the head, thereby lessening the time required to line up the eye with the sights, and providing a firmer hold.

The forward end of a cheek piece as described should fall at a

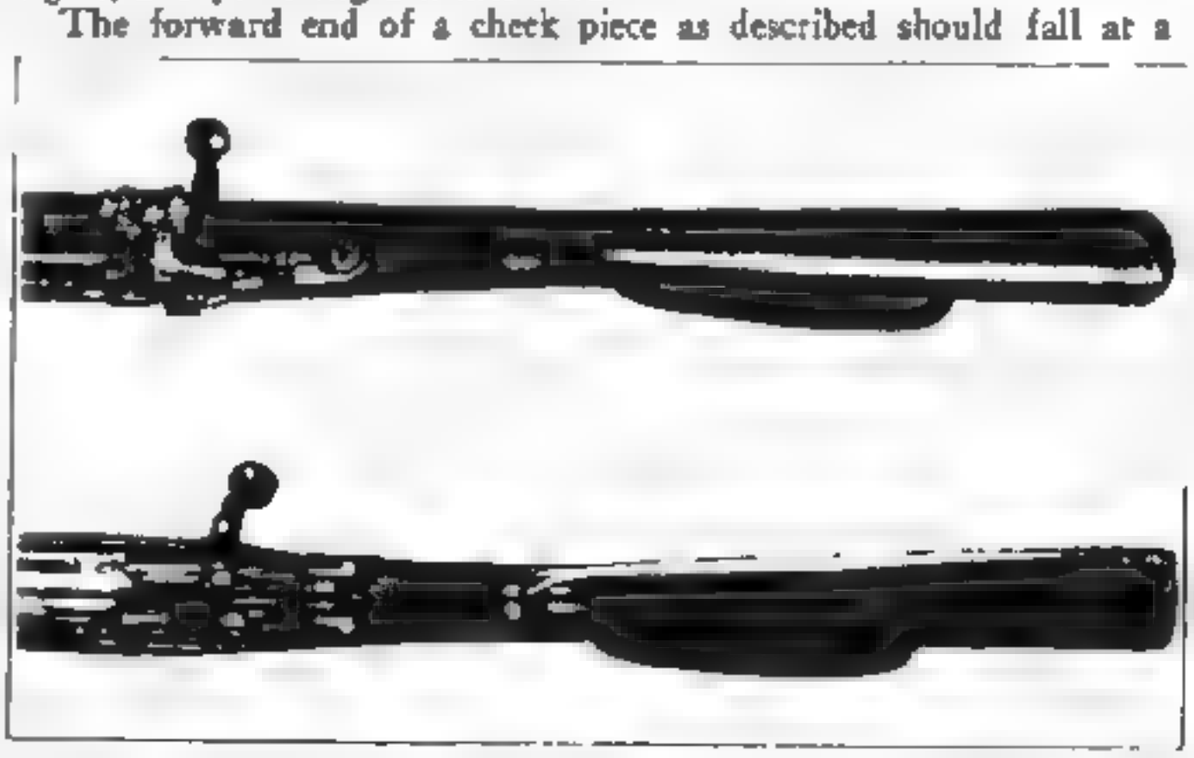

Fig. 50. Upper Whelen—Lower Baker cheek piece

point from 1 1/4 to 2 inches back of the comb—assuming that the comb is set well forward as it should be. There is a type of shooter, however, who "crawls" his stock, shoving his head forward almost touching the cocking piece or hammer—and for him a cheek piece like Figure 52 is of more value. A similar cheek piece is shown in

Figure 53, this being an old Stevens Schutzen stock, on which the cheek piece is extra full and rounded out to what should have been the thickness of the stock itself—if they hadn't made their butt plates so blamed narrow in those days! The type shown in Figure 52 should have the same cross-section formation as the ones previously described, it being merely carried forward.

A friend of mine recently made the stock shown in Figure 54 for a M. 22 Springfield, and uses it with the keenest delight. He is a "stock crawler" in every sense of the word—virtually wrapping his right eyebrow around the sight disk and resting his cheekbone where the grip ought to be! He made this stock out of one of the most beautiful pieces of burl walnut I ever hope to see, and I'd have given a leg, almost, for the privilege of working it into one of a more Christian shape; nevertheless, if this stock fits him and handles right for him, I can't blame him a bit for using it.

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COMBS: Passing the cheek piece in our forward journey on the stock, we come to the comb,—and here is where the cranks yell their views the loudest, and where, in my opinion, stock makers most often fall down. A comb may serve its purpose very well, and still look like a last year's bird nest. Or it may be as gracefully modeled as a flapper's ankle—yet serve no more useful purpose. Probably the first comb ever shaped on a stock was a happen-so—the result of cutting away the wood to form a place to wrap the thumb round—so it was cut back plenty far enough so that there would be no danger of interference with the hand grasp. I said *plenty* far.

Eventually, no doubt, some enterprising shooter discovered that when he slipped his hand back an inch or so, permitting the base of the thumb to be supported by the comb, his hold was much firmer and more steady. The properly designed stock has the comb so placed that when the grip is grasped for shooting, with the finger in position on trigger, the base of thumb is so supported. Just where to place it to get such support is the problem. Some tell us the point of the comb should be over the center of the pistol grip; some say over the rear half of grip. But since the position of the grip may be variable, the rule isn't a good one. Moreover, some shooters grasp the stock with thumb along the right side, while others place it across the grip, grasping it as they would a pitchfork handle. The former can use a comb fully a half inch further forward than can the latter. The type of rear sight has something to do with the location of the comb also. Cocking-piece and bolt sleeve sights often extend so far back as to interfere with the cross-grip unless the comb is cut back a bit.

It is difficult to lay down a hard and fast rule for the position and thickness of the comb—the "cut and try" method being of course

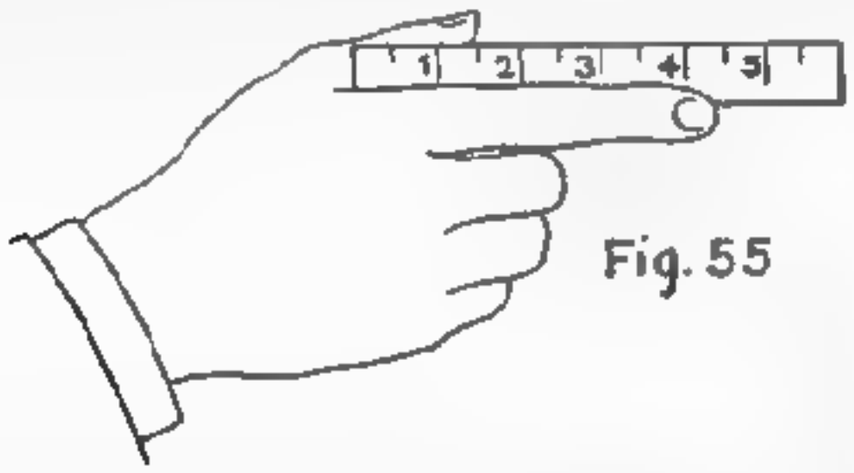

Fig. 55

the most reliable when it is possible. The most reliable method I have found when a try-on of the stock is not possible, is to measure from tip of forefinger to crotch of thumb, then project this measurement from center of trigger to upper edge, (Figure 55). On my

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hand this measurement is just 4 1/2 inches, which is the exact distance from center of trigger to point of comb on the D. C. M. Sporter—and this comb is correct for my hand. Numerous fittings by this method by mail have worked out very satisfactorily.

Formerly, combs were made much too thin, but in recent years both shooters and stock makers have awakened to the advantage of a good thick comb. Here again there is no set rule, and the cut-and-try method is best if it can be followed. If it cannot be, then the best judgment of the stocker should be aided by a photograph of the owner of the gun. The thinner the face the thicker the comb should be, and vice versa. A man with a very thin face can use a comb up to an inch in thickness, while the very full face will require one not more than 3/8 inch. Perhaps the best average is 1/2 inch, which will fit almost anybody fairly well provided the height is right.

It is a mistake to make a comb too thick, or too high; but on most bolt actions it is almost impossible to make it too high. With the comb barely clearing the cocking piece of a Springfield, it will stand from 1 5/8 to 1 7/8 inch below the line of sight, depending on type of sights used. The higher comb is preferable when it can be worked out.

Parenthetically, I know a gunsmith of forty years experience, who, because he considers 1 5/8 inch too much comb drop, solves the problem to his own satisfaction by making the comb higher—and cutting it back a couple of inches so the bolt can be withdrawn! He invariably does this, regardless of the customer's specifications, and all remonstrance is in vain. Forty years has taught him how to make a stock, so he says—and he makes them all to the same dimensions throughout!

The comb may be UNDERCUT or not, as you prefer. But unless you or your stockmaker are adept in shaping an artistic undercut, best make it without. A neat, plain comb, well rounded, and about the same thickness for a distance of half an inch below the upper edge, then gradually swelling to the full thickness of the grip, is very attractive and 100 per cent. practical. If undercut, the overhang should run nearly, but not quite parallel with upper edge of comb—not drop downward at a sharp angle, as it does even on many high priced stocks. And the rear portion of the undercut should blend into the surface of the stock with no perceptible angle, instead of being a harsh, flat cut that looks like it was done with a pocket knife. Figure 56 shows the right and wrong way of shaping up an undercut comb. Figure 57 shows the right and wrong way, in my opinion, of shaping the drop to the grip. Here, as elsewhere on the ideal stock, stream lines should prevail. There is no excuse for the sharp downward drop so often seen, nor should this drop, however gradual, carry to the smallest grip diameter.

PISTOL GRIP: The smallest diameter of the grip should be just back of the tang, and at the lower end where the grip cap is

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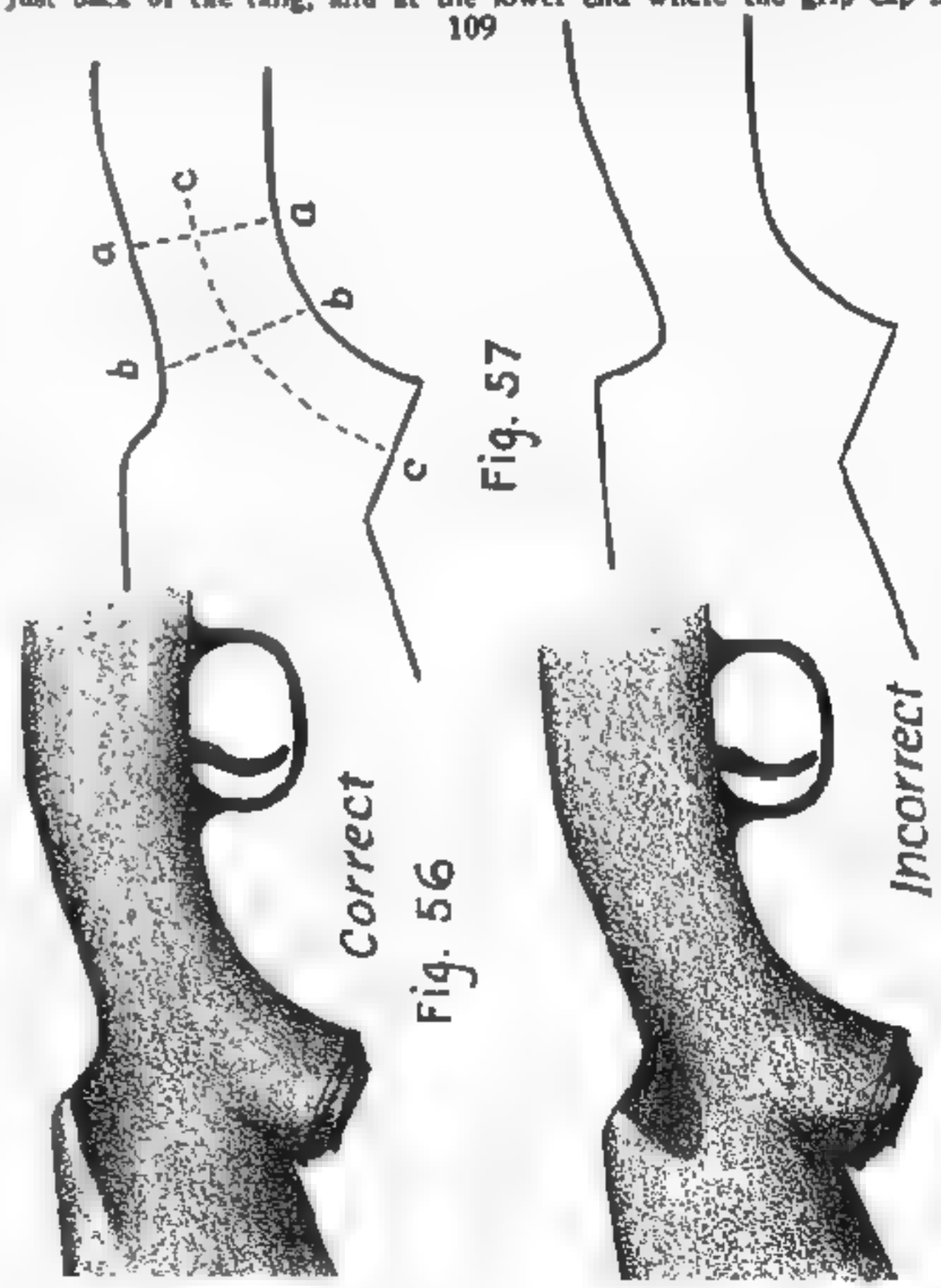

Fig. 56

Fig. 57

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fitted, if one is used. We speak of the circumference of grip inadviasdly, since in the well shaped stock it cannot be the same circumference at all points. The specified diameter should be given it about 1/2 inch back of tang, (on the line a-a, Figure 57), while the circumference just forward of the comb will be slightly greater, (line b-b). The circumference at bottom end where cap is fitted

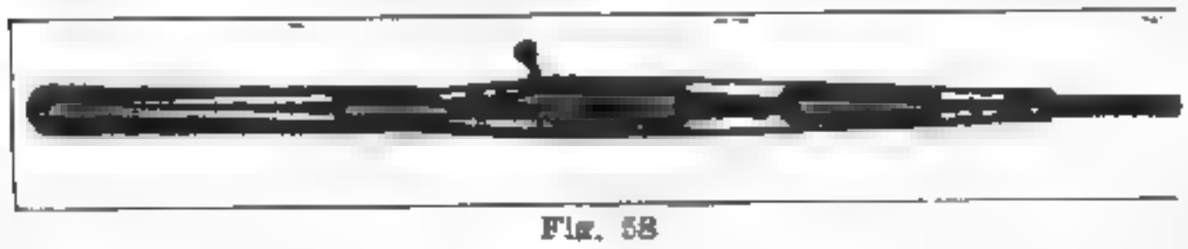

Fig. 58

should be about the same as at a-a. The sides of grip should be about parallel along the line c-c, except that a slight swell on the right side to fill the hollow of the palm is quite permissible, and often desirable. This was a feature of Ludwig Wundhammer's stocks which pleased many shooters so much. This swell is quite noticeable on the Springfield sporter stock of which a bottom view is shown in Figure 58.

Now we come to the length of the pistol grip, i. e., the distance from center of trigger to nearest point of grip cap. Recent decisions from headquarters are to the effect that this distance should be from 3 1/4 to 3 5/8 inches—4 inches being the extreme for the largest hands. Now I'll probably raise a storm of protest with a statement that this dimension doesn't mean a blamed thing—and I'm going to try to prove my assertion with Figure 59. Here are shown a number of different grips drawn to exact scale, and each one measuring exactly 3 1/2 inches from center of trigger. Test it on the cut with a pair of dividers. The curve of the grip, whether an arc or a parabola, and the *vertical* distance of the point "x" below the center of trigger, in its relation with the distance from trigger, is what determines the grip's efficiency or lack of it. In Figure 59, "G" is the grip of the D. C. M. Sporter stock as issued; while "H" is the same grip slightly altered, but with the distance from trigger *not* increased. The curve was originally an arc of a circle; it is cut back in "H" to a parabola, i. e., the curve increasing toward the end. In theory the "as issued" grip looks better, and seems like a closer grip; but handling the two shows that the one at "H" gives the firmer hold—the sharper curve at lower end giving a "hook" effect, while there is a slight but decidedly noticeable tendency for the hand to slip down and back on the other.

The best grip I know of is one having a slight parabolical curve toward the rear, with plenty of finger room just back of guard; the length from center of trigger to edge of grip-cap to be anything de-

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sired from 3 1/4 to 4 inches; and the *vertical* distance from edge of grip cap to center of trigger, about 1 1/2 inches.

I am not in sympathy with extreme grips like some of those in Figure 59 projecting straight downward, which form a projection from the stock at their rear edge. The most graceful grip is the one whose bottom edge just meets and forms an angle with the bottom line of stock. If a grip cap is used it will project something like 1/4 inch, which is sufficient for appearance's sake.

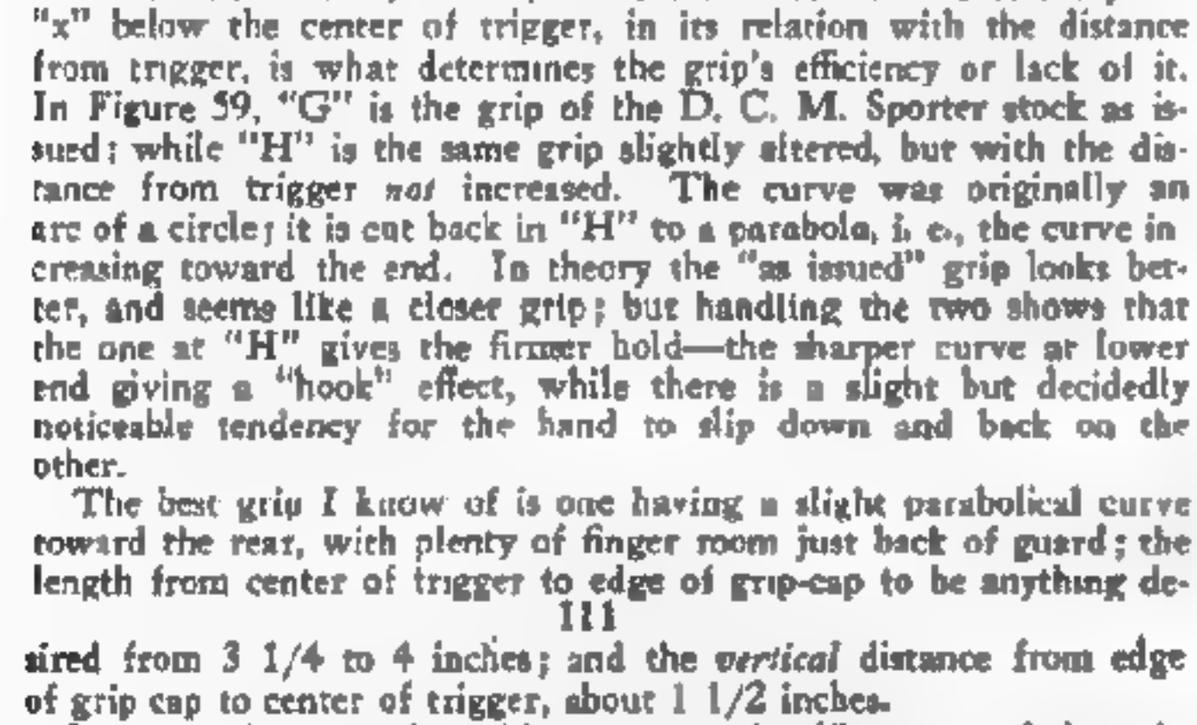

Fig. 59

An important point is the angle of bottom of grip and its forward edge. When these surfaces form an acute angle like "a", Figure 60, the grip looks like something had been forgotten; and a widely obtuse angle like "b" is equally undesirable, indicating either a grip carried too far back, or a stock that is too shallow from top of comb to a point behind the grip. A right angle, as at "c" gives a properly shaped grip of splendid appearance, and permits a full sized grip-cap, and about the right depth at comb.

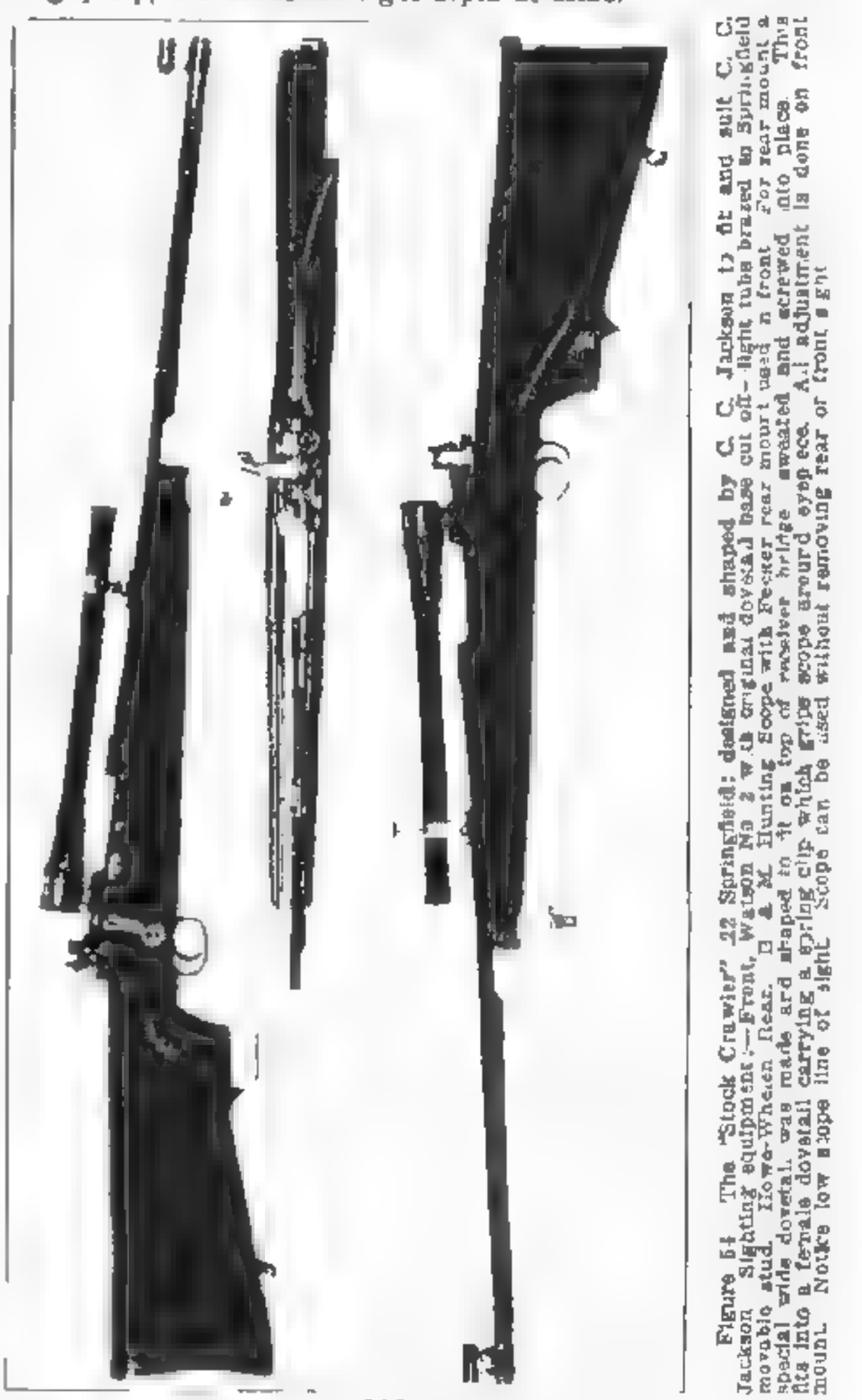

Figure 54 The "Stock Crawford" 22 Springfield; designed and shaped by C. C. Jackson to fit and suit C. C. Jackson. Sighting equipment:—Front, Watson No 2 wide original dovetail base cut off—light tube brazed to Springfield movable stud. Howe-Wheeler Rear. D & M Hunting Scope with Fecker rear mount used in front. For rear mount a special wide dovetail was made and screwed into place. This fits into a female dovetail carrying a spring clip which grips scope around eyepiece. All adjustment is done on front mount. Notice low scope line of sight. Scope can be used without removing rear or front sight

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This depth, or vertical distance from comb to point just back of grip, is another point where many stockmakers fall down. Too shallow a stock at this point always results in a grip set far back and virtually useless; and such a stock, if not actually lacking in strength, at least gives the impression of flimsiness. Again, too great a depth at this point ruins the lines and makes any stock look like a boat oar. The attempts of some of the factories to design a stock with pistol grip well forward has resulted in just this effect—it is particularly noticeable in the old Model 20 Savage stock, which I honestly believe to be one of the homeliest ever produced The new Model 20 is much better in this respect.

There is no set rule for thickness of the grip, but experience has

Fig 60

shown that it should be from 4 3/4 to 5 1/4 inches in circumference. My preference is 5 inches in American walnut, and 4 7/8 inches in high grade European which usually is a little stronger and harder. In cross section I favor a grip of very full oval—not round, but much more nearly round than many stockers make them. The oval outline, Figure 61, is 5 1/2 inches in circumference, and an oval in these proportions seems to be about right. The grip can be roughed out to this outline, then reduced in finishing to the desired diameter without changing the proportions.

BUTTSTOCK: The stock immediately back of the grip should be the same thickness as the grip. A grip bulging out from sides of stock looks like the devil—or worse. The bottom edge just back of grip should be full and rounded to about a half circle, and narrowing in a straight taper toward the toe to conform to shape of buttplate. This is just the reverse of the upper edge of stock, which is thick and full rounded at butt end, narrowing in a straight taper toward the comb. The thickness and shape of butt is controlled by the shape of the buttplate, the shape and dimensions shown in Figure 62 being about ideal. If your buttplate does not conform to your ideas of what you want, it should be filed to shape before fitting, then the stock worked down to it. The top and bottom lines of stock should be *absolutely straight*. There is no excuse in rhyme nor reason for the shadbelly curve often seen on old stocks, but now, thank the Lord, disappearing. A very slight fullness may be permissible on the sides when it is desired to gain weight, but the side surfaces should run as nearly straight as possible from buttplate to grip. I may add also that thick, bulging sides on a stock do not add enough weight to materially reduce recoil. If a buttplate of

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the desired size and shape is not available, thickening the stock ahead

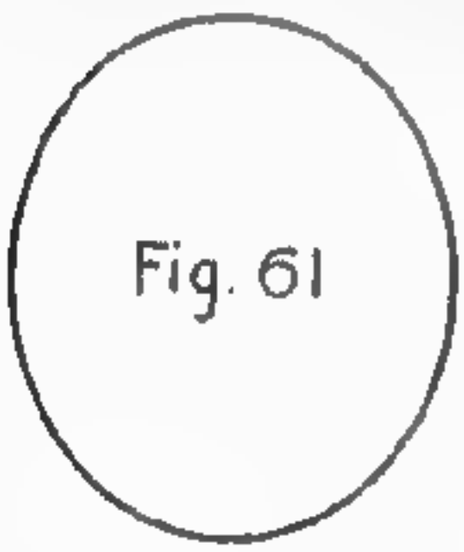

Fig. 61

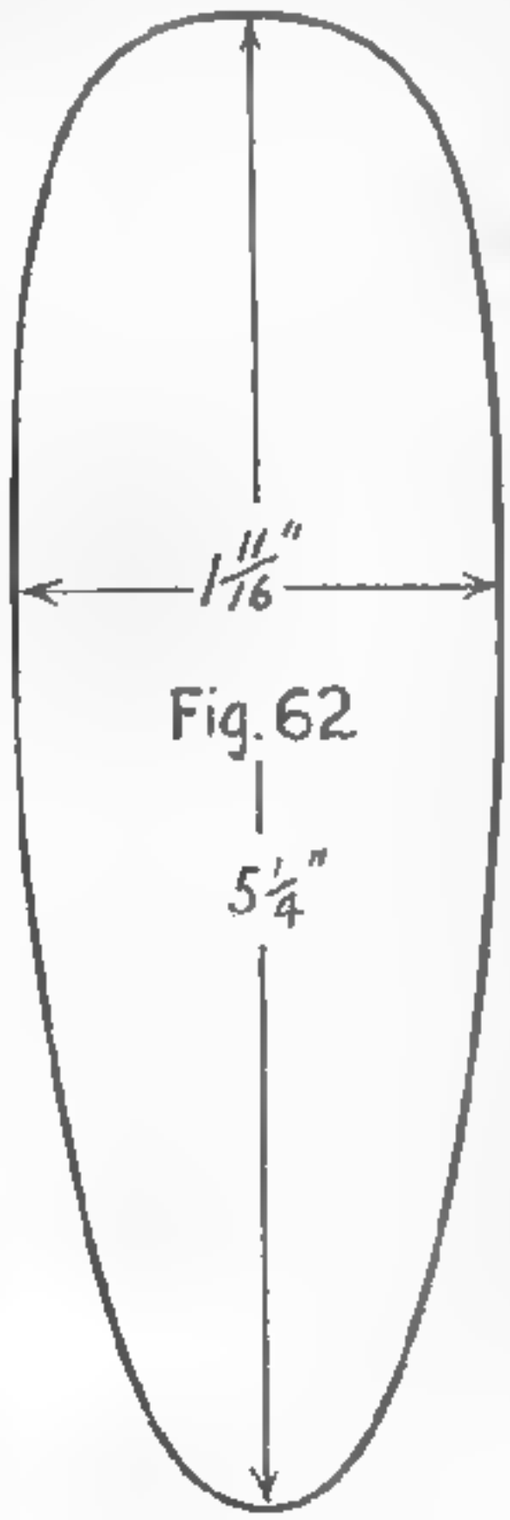

Fig. 62

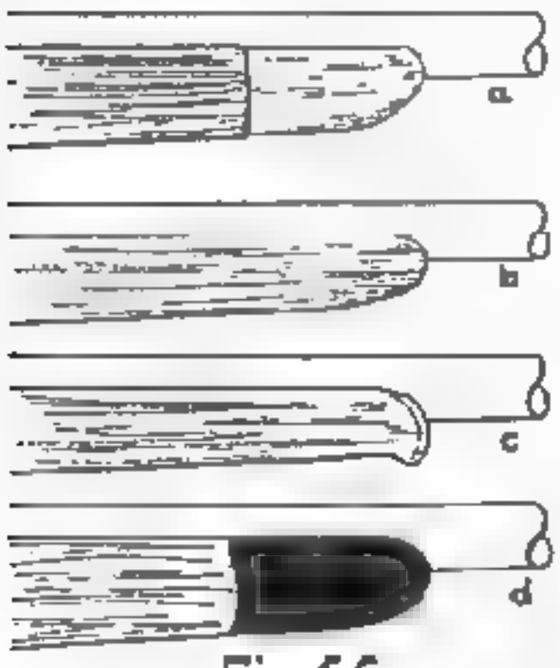

Fig. 66

of butt will add only an ounce or so. It is area of buttplate, not stock thickness at sides, that distributes the recoil over an area which makes it less noticeable. Recoil in a rifle of .30-06 or lesser caliber should not, in my opinion, bother any man physically capable of carrying a gun in the woods—particularly if the stock is properly designed and shaped. But if the shooter is sensitive to recoil and must be protected from it, he should use a rubber recoil pad, especially if he cannot get a buttplate of the proper size and dimensions.

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ACTION SIDES: Beginning at a point slightly back of the tang, the stock of a bolt action rifle commences to swell to accommodate the action mortices. Many leading stockers apparently try how thin and flimsy they can make the stock at this point. True, a rifle is more easily carried if not too thick where the hand naturally grasps it, at the point of balance. But strength is even more important, and right here where the magazine and receiver are let in is the thinnest point on the stock. If the grain happens to take a slight side turn about this point, you can expect the stock to split or break almost certainly, sooner or later. I am convinced that the stock should be at least 1 7/8 inches through at the thickest point, which as I shape them, comes 1/2 inch ahead of rear end of magazine—my own are 2 inches at this point, and oval in cross section, not slab sided. This applies to all bolt actions in big game calibers. A stock by a famous maker which is now on hand for duplication measures but 1 5/8 inch at this point, and the sides are flat as the proverbial pancake. An additional 1/8 inch of wood at center would have made a more pleasing stock, with far greater strength, and the increase in weight would have been trifling.

There is another big advantage in having a stock extra full over the action; its lines can be carried forward in a straight taper, or very nearly straight, to tip of forend, and the forend thus formed will be a comfortable handful instead of the ridiculous sliver found on so many rifles.

FORENDS: I am a staunch believer in the comparatively full forend; yet I do not want it at the expense of handsome lines in the balance of the stock, nor is it necessary to gain it in this way. The stock above mentioned which is 2 inches thick over the magazine, tapers to 1 1/4 inch at forend tip, and thickness at point where hand grasps forend is 11/16 inch. This is just 1/16 under the 1 3/4

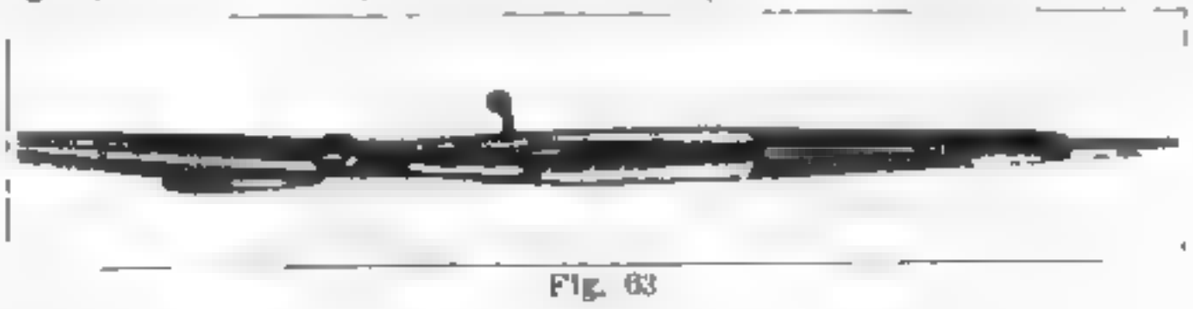

Fig. 63

inch endorsed by Captain Crossman and this extra sixteenth of an inch could be added without appreciably changing the contour of the stock, which, as will be noted from Figure 63, is not extreme at any point, unless it is in the length of the forend.

I like long forends. I like them longer by an inch or so than most stockers recommend, the usual length being nine to ten inches

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from receiver, while this one is 11 1/2 inches. Such a forend adds a bit of weight out toward the muzzle where it is needed to balance the rifle having a light barrel with comparatively thick buttstock. It permits the shooter to grasp the forend well forward, for better control of the piece. And it permits of better lines in the entire stock. And finally, it eliminates to a large degree, the skinny appearance of a rifle with thin barrel; and when the forend is made comfortably hand filling, the extra or so length relieves the otherwise chunky effect.

But then, I can carry and use a rifle weighing 8 1/4 pounds. I weigh 160 pounds and am 5 feet 7 1/2 inches tall—which means I'm carrying a few pounds of fat that I shouldn't have, and wouldn't have, if able to spend more time afield using my guns, instead of in the shop working on them. Nevertheless I prefer this rifle to a lighter one—its weight is a real help after a puffing climb up a hill when a quick shot presents itself. It balances like a shotgun, is very quick handling, and actually feels lighter and swings faster for me than some others weighing nearly a pound less.

If asked to lay down a general rule for forearm length, I think

I would make it read this way: Let the distance from receiver to extreme tip of forend equal approximately half the barrel's length, but not in excess of a 12 1/2 inch forend—provided this dimension permits placing the front sling swivel from 15 to 18 inches ahead of trigger. If the swivel is attached to barrel ahead of forend, this point can of course be ignored. If it goes through the forend it will be necessary to have it of such a length as to permit the desired distance. The swivel will look better if placed 2 or 2 1/2 inches back from tip of forend.

I often wonder if some of the gunsmiths who insist on giving us very short forends are not thinking of the extra time required to inlet a barrel into the longer one, and of the extra care which must be exercised to bed the barrel with even pressure at all points. This does greatly increase the labor, and the difficulty of it, and the beginner may well be excused for making his forend the minimum length which he can handle to advantage.

In cross section the forend may be any shape that rests comfortably in the hand with a minimum tendency toward rocking or canting. Whelen prefers a forend nearly cylindrical in shape. Some of our best stockmakers shape them nearly flat on the sides, sharply rounded on the bottom. My own choice is a modified pear shape like Figure 64A—nearly flat on bottom, slight bulge on sides, and drawing in toward barrel at upper edges. This shape should blend gradually into lines of stock over action, and should also taper off forward to the tip.

Figure 65 shows a Springfield stock which is one of the best examples I ever saw of how a stock should *not* be designed. The comb is too low, and sets too far back. The grip has the "hook"

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effect previously advocated, but too much of it, and it is too thick—six inches in circumference. Buttplate is too narrow, barely 1 1/2 inch wide, and the stock swells out into a regular Molly Fullbosom in the middle. The side panels have no place on a modern rifle;

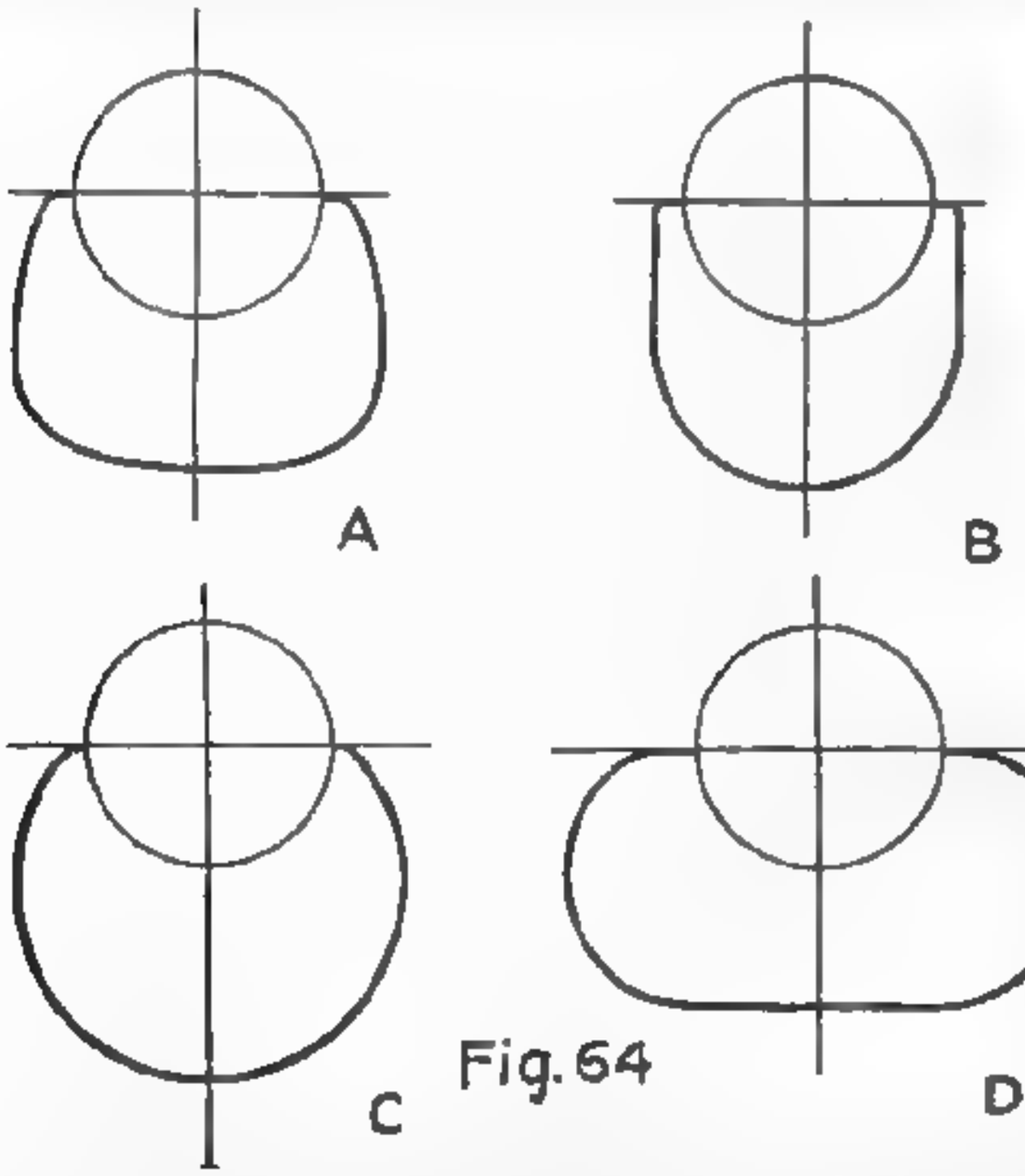

Fig. 64

they serve no useful purpose, spoil the lines, and make the gun very clumsy. This particular stock is 2 1/2 inches through the panels!—while the forend where left hand grips it is but 1 3/16 inch thick and is V-shaped on bottom edge. Note, also, that this enterprising gunsmith has saved himself a few hours work by making the upper edge of forend coincide with the receiver where the shells are ejected, instead of bedding the barrel to half its depth, as it should be, and the line dropping to edge of receiver at rear of barrel ring. A comparison of the two close-ups in Figure 65B and Figure 65C will make this clear.

Upper Figure 65 a good example of how NOT to design and stock a rifle. Lower Figure 65C, a properly designed sporter with close grip, high comb and full forend.

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The last point for consideration on our stock is the FOREND TIP. This may be shaped in a variety of ways, as shown in Figure 66, in which "a" illustrates the shape commonly used on Krag carbines and D. M. C. Springfield Sporters—practical enough, but scarcely ornamental; "b" is the English idea of a plain forend; "c" shows one of the several types of snobble that Crossman haughtily refers to as a "chair leg", and which is seen at its worst on the Savage bolt actions and Model 30 Remingtons as stocked by the factories; "d" is a tip of carabao (Asiatic buffalo) horn, ebony, bakelite, ivory, or other material, and is usually shaped like the plain tip shown at "b", although some makers shape it into a snobble if desired.

The properly designed snobble is not so unattractive—in fact, some of the older ones seem to me particularly graceful, but it must be admitted that those seen in recent years merit all the criticism they have received. The average shooter may wonder just why such designs were made, and wonder if the designers are proud of them. I think it likely they are not. Doubtless the reason for such abortions lies in the modern idea of cheap, rapid machine production. It is reasonable to suppose that much more hand shaping and finishing was done on stocks formerly than is done today. Such a graceful, well proportioned forend as that found on the old Winchester Single Shot rifles, for example, could not have been shaped by machinery. The snobble on this forend, by the way, is ideal, and can be copied on almost any stock without detracting from its appearance.

Factory stocks are shaped in what is known as a copying lathe, which operates on the same principle as the little machine locksmiths

use to cut duplicate keys. The stock blank is mounted between centers, in line with a cast iron pattern stock, and both are revolved slowly. A cutter wheel running at high speed is brought against the stock blank, and this is guided by a guide wheel bearing against the iron pattern stock. About one minute or less is required to rough out a stock to shape. The cutter wheel, being about six inches in diameter and an inch in thickness, the knives set around its periphery taking a cut at least 1/4 inch wide, it is evident that minute details of stock formation cannot be followed with such a device; hence the stock must receive its final formation by hand. Having seen stocks being rough turned, an inspection of many factory models will convince anyone that quick finishing, with minimum hand labor, has played an important part in the shape selected by the makers, rather than any thought of beauty or utility. Which is one more reason for making, or having your stock made by hand.

TWO PIECE STOCKS: Thus far our attention has been principally centered on the more or less conventional sporter type of rifle stock. We must now consider others designed for a special purpose, or whose design is limited by the type of action used.

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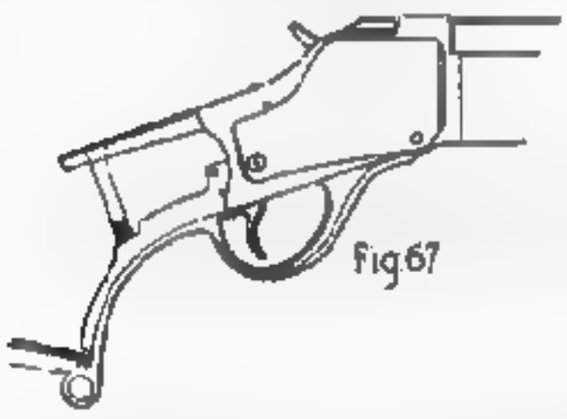
The one piece bolt action stock was chosen for discussion first, because it embodies practically all of the points found in other stocks, and some of its own besides. Two piece stocks, as required on various single shot rifles, should follow pretty much the same lines as the ideal one piece stock. There are certain features of the actions, however, that may necessitate modifications. For example, the long upper tang may force the stocker to cut the comb back further than it should be. A straight lower tang may preclude the possibility of using a pistol grip. On most single shot actions this lower tang may be bent to form a fairly good grip, but on some repeaters this is impossible, due to action parts extending back into the stock.



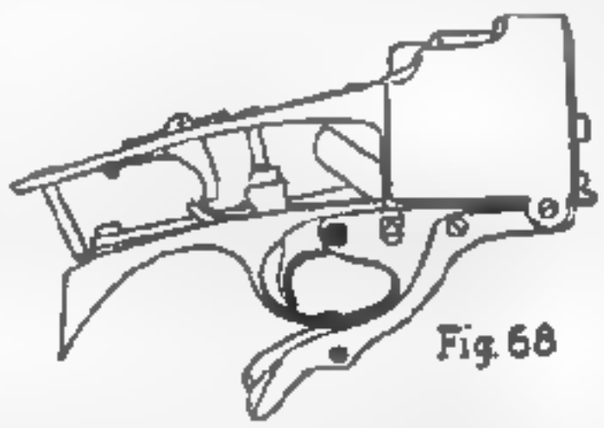


Figure 67 shows a Single Shot Winchester remodeled for a customer to his own ideas. Details of this job are described fully in Chapter 30. A comparison of this with the original factory design shows very clearly the increased beauty and improved handling qualities possible as a result of re-designing and hand workmanship.

The Farquahrson falling block S. S. action, made in England has its lower tang well shaped for a full pistol grip. (Figure 68) American gunsmiths have awakened to the possibilities of this splendid action, and a good many of them are being imported and fitted with American made barrels and stocks.

Figure 69 illustrates a .22 caliber target rifle on Martini action first designed by Mr. Russel Wiles. This is an unusual stock, and an unusual forend, but well adapted to the particular use for which the gun was designed. The sights, both front and rear, are removable, and the stock is made so straight and with comb so high as to give the same drop dimensions when using telescope, as when the scope is removed and iron sights attached. The beaver-tail forend is unusally heavy and stiff, with its forward section to which the sling is attached, forming an abutment against which the crotch of the hand rests in firing. This permits a very rigid hold with tight sling, and eliminates the discomfort of the front swivel digging into the back of the hand.

The beaver-tail forend is preferred by many target shooters, and while somewhat clumsy in appearance it permits of a very steady hold. In its usual form the cross section is about like

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Figure 70, flat on the bottom and flaring very full on the sides. Quite often such a forend is made wider at the forward end than at the receiver; sometimes the widest section is in the center, at the normal hand grip. Both of these patterns I believe to be wrong —I think the forend, regardless of its type, should taper slightly toward its tip. This for the reason that the left hand will invariably exert some backward pull on the forend; and the firmer hold is possible when the hand has an increased thickness of wood behind it to pull against. See also Figure 64D.

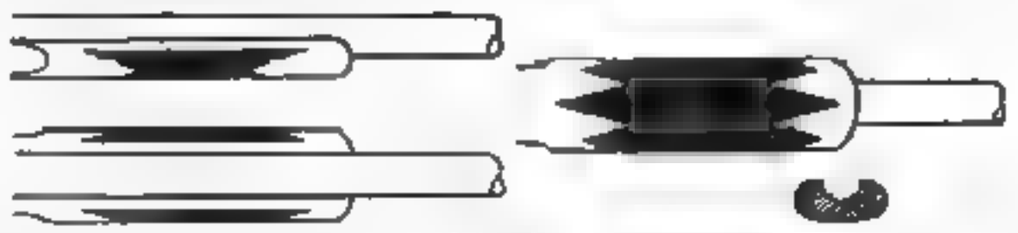

Fig. 70

Most of the light .22 caliber repeaters are very poorly stocked; and while their actions place a good many limitations in the way of the stock designer, it is nevertheless possible to greatly improve their handling qualities. A longer stock with larger buttplate; less drop at heel; a higher and thicker comb; a pistol grip if the action permits; and a thicker, better shaped, and possibly longer forend, will often make such an arm handle like a real gun instead of like a toy.

The 99 model Savage is another that may be re-stocked to good advantage. Figure 71 shows a special job on one of these rifles, which resulted in at least 100% improvement in its handling. A higher comb is the thing most needed on this rifle as turned out by the factory, with a thicker grip, larger buttplate, and larger forend next in order of importance.

SHOTGUN STOCKS: Thus far I have said little about shotgun stocks. Fitting in the lock action of a double gun, either box or side locks, is a job beyond the reach of any amateur workman until he has had considerable experience and spoiled a few stocks. Yet some consideration of the essential points of shotgun fit will be of value to the man having a gun stocked to order, or who through courage and perseverance will eventually stock his own gun.

The author lays no claims to being an expert with the shotgun. The rifle is "my dish". I don't even like to stock shotguns, as the work, in my hands progresses far more slowly than the work on a rifle stock, and becomes irksome. I have my own ideas on the subject of shotgun stock design and fit, which I will give for whatever they may be worth; and the reader is referred to the more extensive and comprehensive views of Charles Askins, Paul B. Jenkins, E. C. Crossman, and others, as expressed in their various books and frequent magazine articles.

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The shotgun stock should invariably be longer and straighter than the rifle stock; and the gun intended for use at the traps both longer and straighter than for field use.

Shotgun shooters are as a rule, somewhat superstitious in their beliefs as to the way their guns perform. A straight stock with a high comb will not make the gun itself shoot one bit higher; but it will make the owner *shoot it higher*, by forcing his eye higher above the rib, which amounts to the same thing as raising a rear sight. Another thing the straighter stock will do, is to absorb recoil better, and eliminate much of the "jump" of the barrel when fired, which jump, while it does not occur until the charge is out of the barrel, usually causes the shooter to believe it is responsible for wild shots.

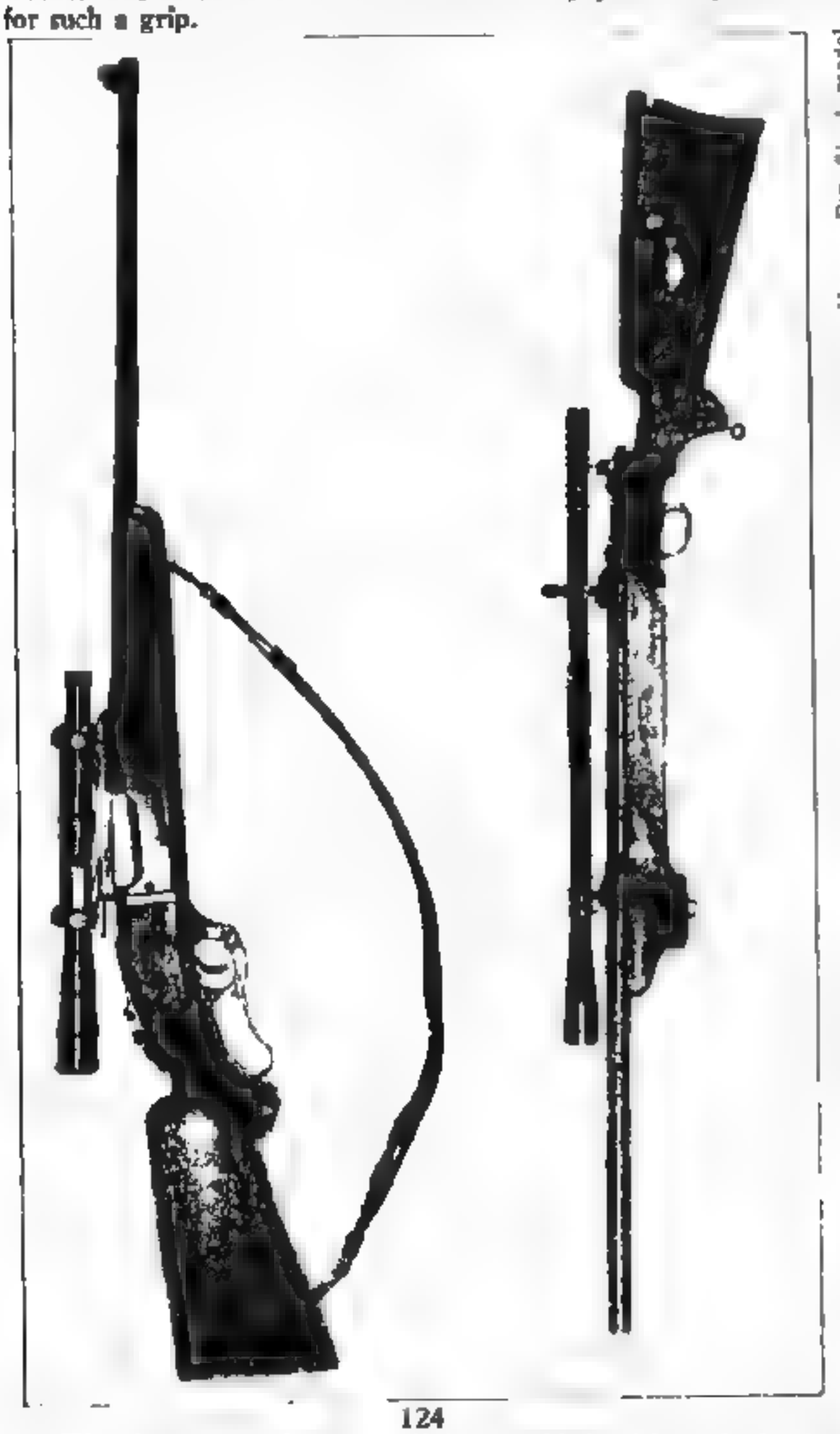
Due to its triggers placed an inch or more apart, the double gun must always be stocked on a compromise. I thoroughly concur in Charles Askins' belief that the left barrel should be the more open bored of the two, so that the rear trigger will be fired first. Since 90 per cent. of one's shooting will be singles, the stock which is dimensioned from the rear trigger as a starting point can be given a more comfortable shape for 90 per cent. of one's shooting. When the front trigger is used for the first shot—which is to say, for most of the shots taken, the sloping rear portion of the guard often punishes the second finger severely, and a habit of flinching develops.

Despite the usual practice of stockers, there is no good reason for making the grip of a shotgun so thin and fragile that it is easily broken. The shotgun grip should be comfortably handfilling, the same as a rifle grip, and it should be a full oval in cross section, not diamond shaped, as many foreign stockers make it.

The comb is set much further back on most shotguns than is necessary—no reason that I know of why it should not be of some use in supporting the thumb, the same as on a rifle stock. True, the shotgun is handled more quickly, as a rule, than is the rifle;—all the more reason why it should be fitted so perfectly that the same hold would become automatic.

Shooters argue a lot over the value of a pistol grip on a shotgun. What most makers call a pistol grip is nothing more than a pimple about the center of the stock's bottom edge. As to provide a steadier hold, it certainly does not. But if we design a full pistol grip similar to our ideal rifle grip, and place it in the proper relation to one of the triggers, it will be largely useless when we are using the other trigger. For this reason it is generally conceded that the straight grip is preferable on a double gun: while giving more racy lines to the stock, it also permits a quick shift from one trigger to the other, without altering the feel of the grip.

When using a gun fitted with single trigger, or a single barrel trap gun, pump gun, or automatic, the pistol grip can, if desired, be worked out so as to be of real use—and my personal preference is for such a grip.



Upper: Fig. 71 A model target rifle [illegible] solely for shooting in the prone [illegible] fitted with hunting scope.

Lower Fig. 69 A .22 [illegible] 10 Savage restocked and fitted

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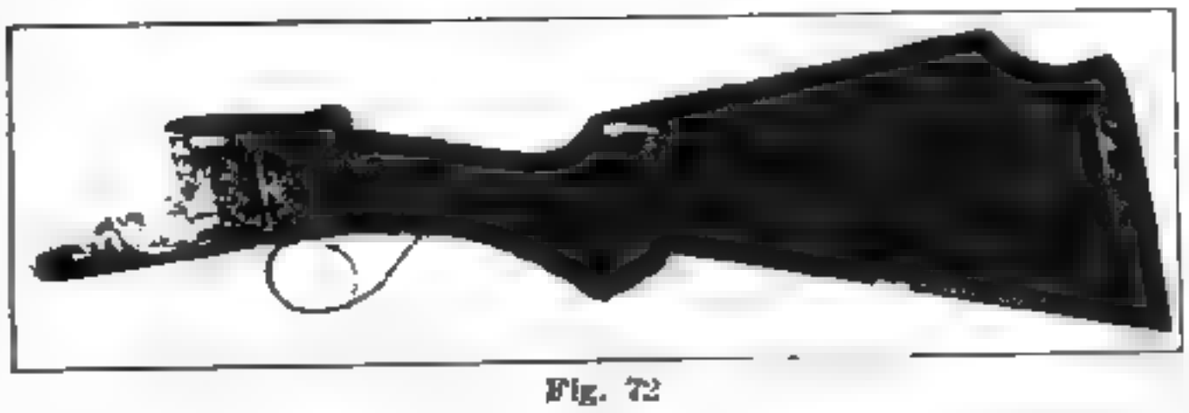

Fig. 72

ferred by a number of shooters after years of experimenting with stocks. They claim that such lines speed up the aim and prevent over or undershooting, since the aiming eye is held at the same relative height above the rib, no matter where the stock may be cheeked.

The man with a long neck or very sloping shoulders, however, finds that such a stock brings the butt too high on his shoulder so the solution for him is a Monte Carlo comb as shown in Figure 72. This gives all the advantage of a high, level comb, yet permits the necessary heel drop to bring the butt snugly into the hollow of the shoulder.

We hear so much about the high comb and its desirability on both rifle and shotgun, that the man designing his first stock may well heed a word of warning on this point. Theoretically the perfect comb is one which when the cheek is pressed quite hard against it, with the cheekbone resting snugly on the top edge, the right eye will

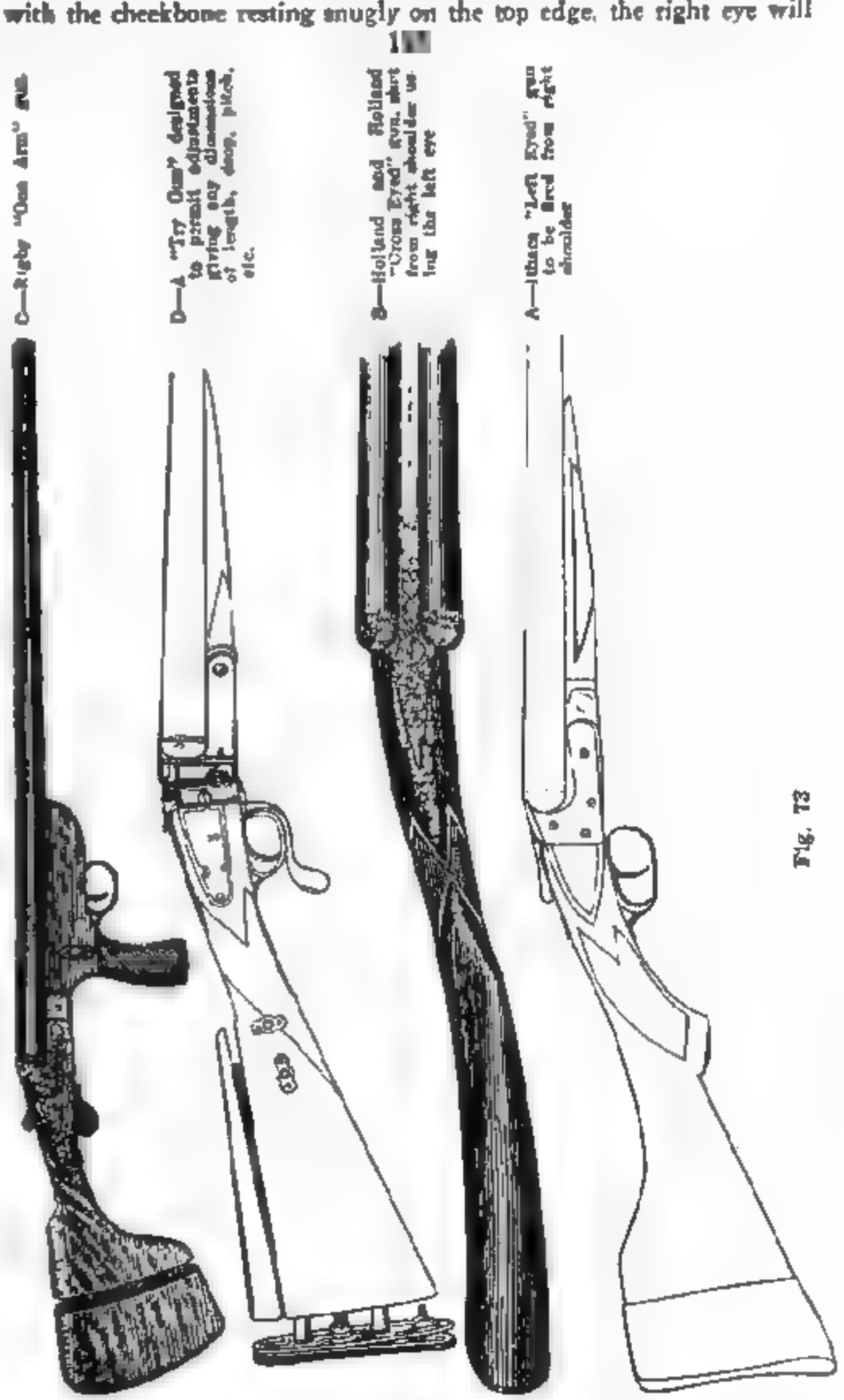

Fig. 73

be looking though the line of sights. I once stocked a rifle in this manner and took it to the range for testing. After half a dozen shots I was quite ready to sacrifice some of this ultra perfect stock fit for a bit of comfort—the punishment my cheek bone took from that comb was equivalent to a first class slugging, and the spot remained sore and bruised for a week afterward. Such a fit may well

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be sought on the very light caliber rifles—but not on a big game rifle or a shotgun.

FREAK STOCKS. Numerous "freak" stocks have been built for shooters having some physical deformity or impairment, and serve their intended purpose admirably. Figure 73 shows a few such guns. "A" is an Ithaca stock designed for a right handed shooter who, through impairment of vision, must shoot with the left eye; the comb is cut away to permit of laying the face well across the stock. "B" is the Holland and Holland "Cross-Eyed" gun to fill the same need. A job of this sort is necessarily more expensive than the cut-away stock of the Ithaca, since the stock wood must be selected with a natural bend to give it sufficient strength, and the

Upper: Fig. 73—Remington trap forend.
Lower: Fig. 74—Ithaca beavertail forend.

rear portion of the action is built with a bend to the right. "C" shows the Rigby One-Arm Gun, developed principally as a result of the World War. As one hand has to do all the work, it was necessary to give a grip at the best point of balance. This necessitated carrying the trigger mechanism well forward of the breech, with consequent shortening of the stock because of the longer arm reach. A single trigger is also essential, and is connected to the action by means of steel rods, while a thumb operated safety is placed on the right or left side of grip, according to whether the right or left hand remains. Since but one hand is available to hold the gun against recoil, shock springs have been inserted in the butt stock, and being held in line with light metal pistons the recoil is efficiently absorbed with minimum disturbance of aim.

Shotgun shooters are gradually turning from the small forend to the larger, handfilling type on all classes of guns. The beavertail is preferred on single trap guns, and is often seen on doubles as well. Many field shooters also prefer such a forend on doubles,

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the favorite type being shown in Figure 74. This forend not only protects the hand from the heat of the barrels, but also gives better control of the arm, and at the same time protects the finish of the barrels from wear where the hand grasps them in shooting. The large round forend which is standard on pump guns is very good, but is too short for many shooters, necessitating an uncomfortably long reach with the left arm. To overcome this objection a type known as the "trap-gun" forend has been designed, and can be had on Remington, and perhaps other pump guns at a nominal additional charge. This forend is illustrated in Figure 75.

As a closing injunction to the beginner in the field of gunsmithing, —and perhaps to others who are not beginners, I wish to quote excerpts from an article discovered in a printers' book of type specimens; while referring originally to typography, the advice it gives may so aptly apply to the field of gun design also, that I have thought it worth reproducing, deleting only the references to the original subject:

"The best kind of originality is that which comes after a sound apprenticeship; that which shall prove to be the blending of a firm conception of all useful precedent and the progressive tendencies of an able mind. For, let a man be as able and original as he may, he cannot afford to discard knowledge of what has gone before or what is now going on in his own trade or profession. * * * *

"All those concerned in what are accepted as the fine arts, the learned sciences, and professions, surround themselves with the history, the literature, and concrete examples of the work with which they may be particularly engaged. * * * *

"Art does not flourish in hidden places, nor under restraint, nor in ignorance of what talent and genius have accomplished and are now accomplishing throughout the world. For to follow precedent wisely does not mean to imitate slavishly one great exemplar, but to study all the masters faithfully, letting their great achievements sink slowly into the mind in order that we may patiently derive from the richness of our acquired knowledge and organized system an attitude of our own.

"The sprightly minded young man, who with his first business breath projects the new and startling, inevitably becomes tiresome, and is driven to an early disappearance; while the slower, more solidly endowed student will at least spend as much of his time in avoiding mistakes as in evolving brilliant schemes wherewith to dazzle his contemporaries."

In this chapter I have avoided, as far as possible, laying down exact butt stock dimensions for either rifle or shot gun stocks. These will vary according to the build and characteristics of the shooter, and must be determined by trying out guns until the right fit is found. The following tables give dimensions which will handle well, and be comfortable to a large percentage of shooters:

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AVERAGE BUTT STOCK DIMENSIONS—RIFLE

Length, center of trigger to center of butt plate	13	1/2	in.
Drop at comb	1	11/16	"
Drop at heel	2	7/8	"
Length from heel to point of comb	9	3/4	"
Length from tang to point of comb (on bolt actions)	2	1/2	"
Length from center of trigger to point of comb	4	5/8	"
Length from center of trigger to nearest point of pistol grip cap	3	1/2	"
Drop of front edge of pistol grip cap below center of trigger	1	5/8	"
Length of butt plate	5	1/8	"
Width of butt plate at thickest part	2	11/16	"
Pitch of butt	3	1/2	"
Circumference of grip	4	7/8	"
Castoff at butt — Heel		5/16	"
Castoff at butt — Toe		5/16	"

NOTE These are *average* dimensions—not any one shooter's ideal. A rifle so stocked will fit almost any man fairly well, and most of them perfectly, for either offhand or prone shooting. In the ideal stock both the grip thickness and width of buttplate would be increased slightly—the former to 5 inches, and the latter to 2 3/4 inches. For offhand shooting entirely the heel drop might be increased to 3 or 3 1/2 inches, and for prone shooting entirely might be decreased to 2 1/4 or 2 1/2 inches.

AVERAGE BUTT STOCK DIMENSIONS—SHOTGUN

Length, center of front trigger to center of butt plate	14		in.
Drop at comb	1	1/2	"
Drop at heel	2	1/2	"
Length from heel to point of comb	9	1/2	"
Length from center of forward trigger to point of comb	5		"
Length from rear trigger to nearest point of grip cap (double guns)	3	1/8	"
Length from trigger (single trigger, pump, or automatic) to nearest point of grip cap	3	1/2	"
Drop to front edge of grip cap below center of trigger	1	1/2	"
Length of butt plate or recoil pad	5	1/4	"
Width of butt at thickest part	2	11/16	"
Pitch of butt	0 to 2	1/2	"
Circumference of grip	4 3/4 to 5		"
Castoff at butt		7/16	"

These also are average dimensions, but will come very close to fitting the greatest majority for all round shooting. Stock thickness and grip circumference should be reduced somewhat on light, small bore guns, and increased a trifle on heavy trap and wildfowl guns.

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CHAPTER 10

STOCKMAKING: LAYING OUT AND INLETTING

HAVING selected and procured a piece of wood suitable for a stock, and decided on its form, dimensions and finish, we are ready to go into the subject of actually stocking a rifle or shotgun.

By reason of the many types of stock necessitated by various actions it is plainly impossible to give in one, or even several chapters, detailed instructions for stocking every gun in existence. Our efforts therefore, must be confined to general instructions applying to the principal types commonly used, namely, the one-piece bolt action stock, the two-piece stock in which butt-stock and forend are separated by the action, and the shotgun stock, which is also in two pieces. Examples of the first named are found in the Springfield, the Mausers, the 54 Winchester, 52, 56 and 57 Winchester, Model 30 Remington, the Newton, the Ross, Model '17 Enfield, Models 19 and 23 Savage, the Russian, the Krag, and in fact most military arms. The ancient and honorable .45-70 Springfield comes in this class although not a bolt action, as do many old arms, including all the muzzle loaders, both rifle and shotgun.

In the second class we find all of the lever action rifles—the Winchesters, Marlins, Savages, Remingtons—the trombone or pump actions in all standard makes, and the Winchester, Remington and Browning auto-loaders.

Shotguns, whether single or double barreled, or of the pump, lever, or automatic persuasion, invariably have the stock and forend separate, with the single exception of the muzzle loaders, which have one-piece stocks.

ONE PIECE STOCKS: Since the greatest majority of amateurs are interested in making a sporting stock for a military bolt action rifle, we will start with this type; and we will illustrate on the Springfield, since that is and with good reason, the most popular of all bolt actions.

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Figure 76 shows the complete barrel, receiver and action assembly of a Springfield without the stock. Study it. Set it up on the bench in front of you and familiarize yourself with every curve in the receiver formation. Note carefully the concave and convex surfaces—remembering that wherever a portion of the metal has been hollowed, the wood of the stock at that point will be rounded out to fill it. In inletting the stock you are simply carving out a *reverse*

Fig. 76

impression of the metal parts of the gun. The barrel and receiver may be regarded as the positive, while the stock is the negative of the complete arm.

Now study, *very carefully*, Figures 77 and 78. In Figure 77, A shows the action mortices on a Springfield service stock, cut out on a routing machine in a few minutes. B shows a stock blank inletted for the same action by hand, requiring several hours careful labor. Note particularly the difference in the two from end of tang to rear of magazine mortice. In the machine-made stock contours are limited to the scope of a revolving cutter, while in the hand made job, there are no limitations. Only the wood actually displaced by the steel is removed, thereby greatly increasing the strength, and also helping to absorb vibrations when the gun is fired. Note particularly the extra wood left at "a" in B, Figure 77. This fills up the hollows cut underneath the tang on either side. Note also the cuts "b" and "c" in B, Figure 77. These fit into the portion under rear of receiver which holds the trigger mechanism. Note the difference in method of bedding the rear of tang in the two stocks, the hard-fitted job supporting the metal at all points, while only two or three essential points are supported by wood in the service stock.

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At the point "d" in B, Figure 77, note how the wood extends further forward to bear hard against the recoil lug on under side of the receiver. Thus, in the hand inletted stock the receiver has firm bearing in the wood at points "a," "b," "c," "d" and at rear of tang "e;" while in the machine inletted stock the principal bear-

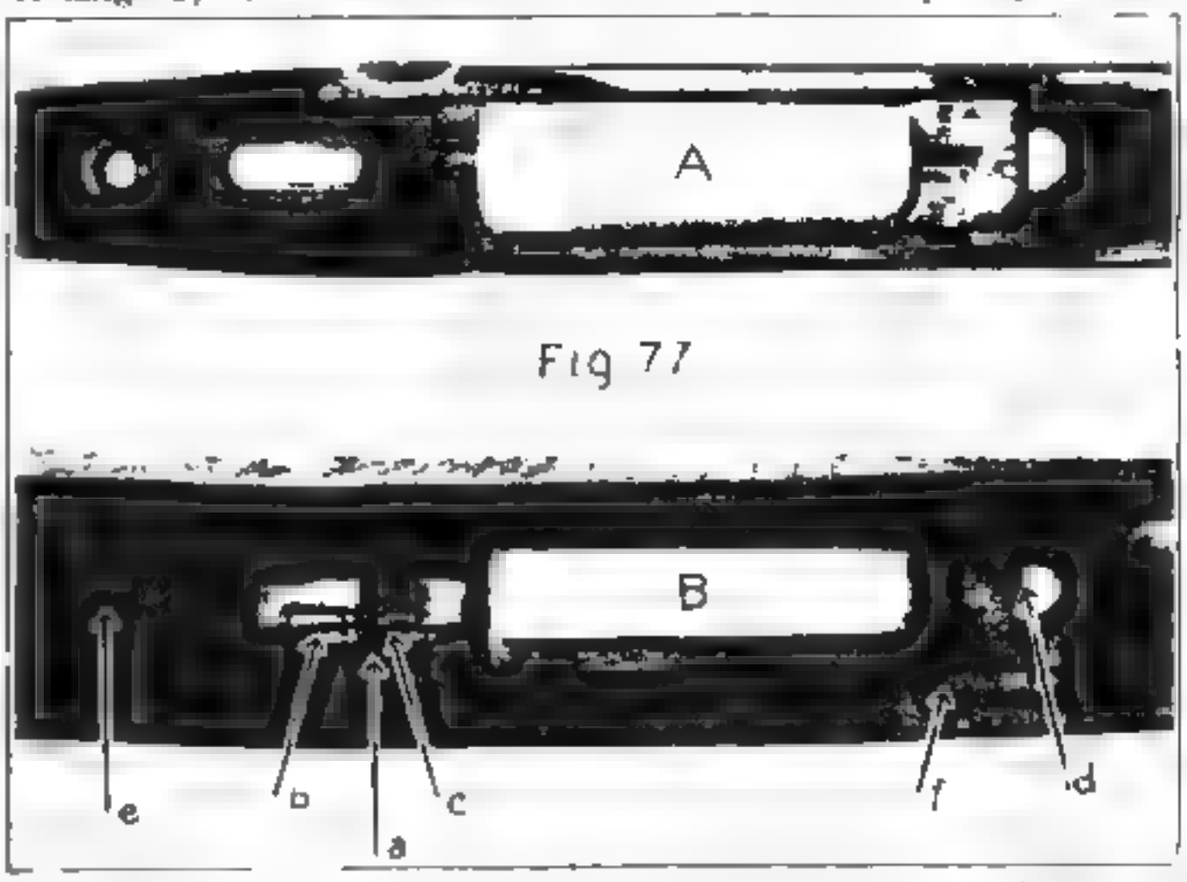

Fig 77

ing is at the recoil lug and rear of tang—two points of support against recoil compared with seven.

Now study Figure 78. This shows a sectional view of the two stocks, one inletted by hand, the other on a routing machine. The difference in the amount of wood left in the stock at its weakest points shows very clearly, indicating the extra margin of strength to be expected of a hand made stock. Now set your barrel and receiver in the machine made stock. Probably you will find that you can move it backward and forward from 1/32 to 1/16 inch. This tolerance is necessary by reason of the inaccuracy of machine fitting, and the slight variations which occur both in stocks and actions; for in quantity production, any action must fit into any stock.

Set the magazine into position and tighten up the guard screws. Now note that there is clearance back of the rear end of tang of about 1/16 inch—this to make sure that there is nothing to prevent the recoil shoulder on receiver from setting back tight against the wood. In our hand fitted stock—assuming that the fitting is properly done, this gap behind the tang is not necessary. For it will be readily

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understood that the thrust of the blunt, round end of the tang against the wood has little if any tendency to split the grip. The reason a grip splits under recoil is usually due to incorrect fitting of the tapered portion of the tang; unless there is reasonable clearance underneath, the tang acts as a wedge, and being unsupported at its rear, it comes right on back. At its upper edge the tang may be fitted quite close to the wood—the clearance should be down inside where it doesn't show. With the wedging effect thus eliminated, the tang supported against rear thrust at the end, and also at the points "a," "b," and "c," in Figure 77, there can be no movement of the action in the stock to start a split. It's the same principle as driving a nail in a board. Try to press the nail in with the hammer, using all your weight and strength, and you will make no headway; but when you swing the hammer on it, it is quickly driven in with moderately light blows.

The amount of wood routed out on the inside of a machine made stock necessitates the use of stock screws to give added strength. In a hand made stock of normal dimensions these are never needed, except for magnum cartridges having very heavy recoil—assuming of course that the stock is of sound, hard wood.

Look again at the point "d" in A, Figure 77, against which the recoil lug bears. The recess for this lug is a trifle wider than the front end of the magazine mortice, consequently, at its extreme outer edges this lug is well supported by solid wood extending clear back along the sides. Certainly the wood is not going to give way at these points. But in the center of this shoulder, there is solid wood for only about an inch, reaching to the magazine mortice.

Evidently, then, heavy pressure against the recoil lug recess in the center will break out this wood. So, if we fit the lug into perfect contact clear across its surface, then relieve the center by taking off a light cut, the back thrust is taken up by the solid wood at the sides, and there is no pressure in the center to cause a break. Thus we can well eliminate the unsightly stock screw at this point, and it is not even necessary to insert a piece of metal on the inside. More often than not the cutting required to fit such a recoil plate actually weakens the stock, while giving the owner false security in the belief that it has strengthened it. Recoil plates and stock screws cannot take the place of perfect hand fitting, with the removal of as little wood as possible.

Note the point "f," at the rear end of the recess which accommodates the projection on right side of receiver. Here is a point often overlooked which may easily develop into a "splitter." It may be fitted quite close on the side, but where it curves in at the rear, there must be a little clearance. Not much is needed—the thickness of a sheet of paper is sufficient, but pressure here must be relieved.

Now take your service stock and turn it over, studying the magazine and guard mortices from the under side. The magazine, being

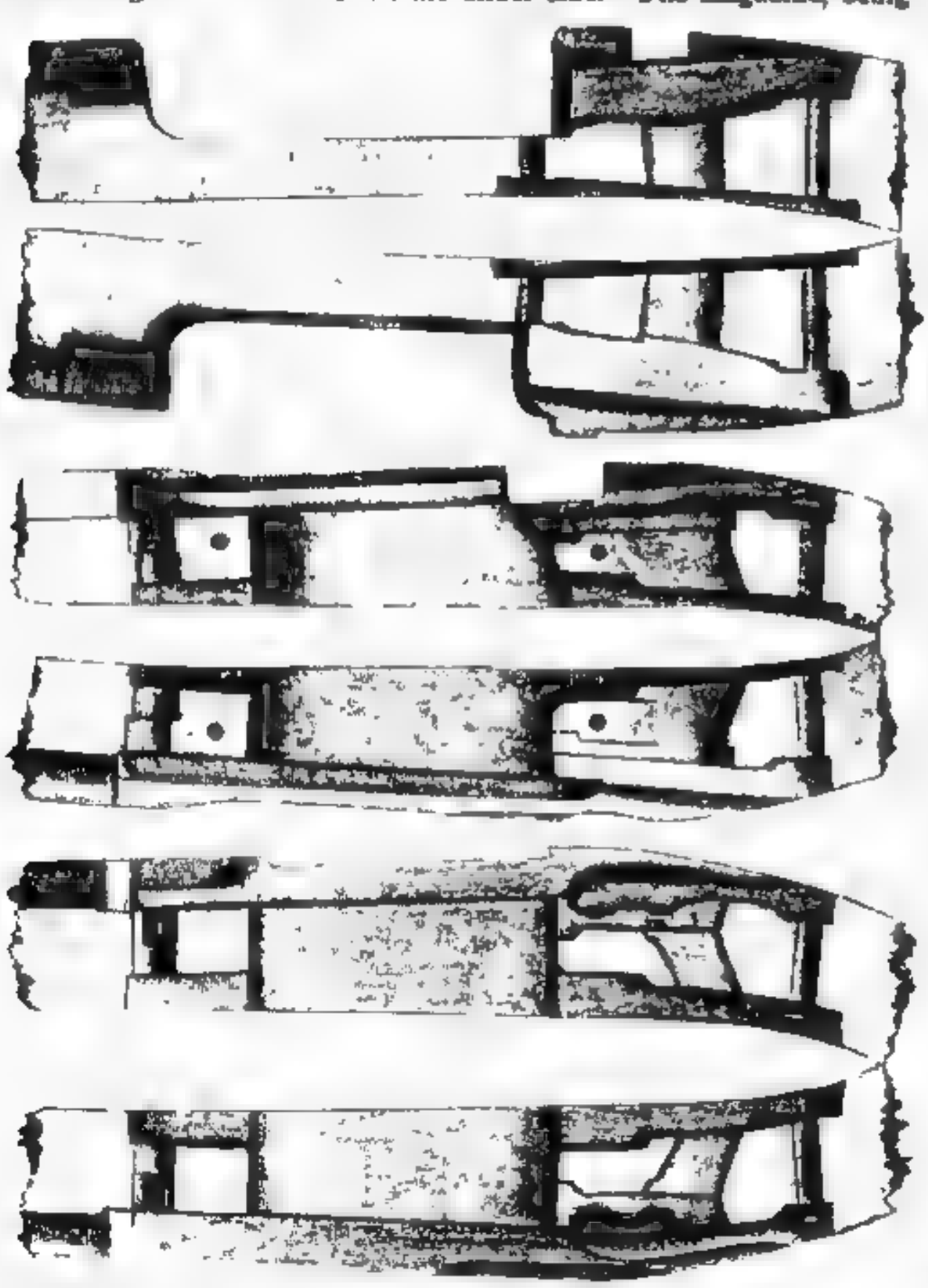

Fig. 78

"Inside facts" on action mortices in stocks. Upper is a Krag stock split lengthwise to show shape of cuts. Center shows inside of machine inletted Springfield service stock. Lower shows inside of a hand inletted stock for Springfield action. Note the several points where extra wood is left in hand made stock resulting in a much stronger stock, with action supported at practically every point absorbing much of the vibration of firing and tending to improve accuracy of the gun. Lower is hand inletted stock

wider at its rear end has no tendency to split the stock under recoil, so the fitting may be quite close at the sides. But, the rounded corners of the rear of magazine, and the inner corners where the guard joins it, ("a" and "b," Figure 79) can develop decided splitting tendencies unless the wood is relieved at these points.

We have dwelt at some length on this analysis of the Springfield stock mortices, to show the reader how to study the requirements of an action, the danger points, and where stock relief must occur. A similar analysis of other stocks will not be necessary; study your action carefully and locate every point to be supported and every point to be relieved. They will be self evident once the principles are understood.

LAYING OUT: Now we are ready to start actual work. To provide an accurate outline of the magazine and guard you will require a templet, which is made as follows: Take the original stock and rub a mixture of lampblack and oil around the edges of the mortice; then press a sheet of stiff white paper firmly over it and rub the paper down smoothly with the fingers. Remove it and you will have a fairly clear outline of the cuts. Carefully trim this out and paste the paper templet on a strip of brass or tin, then file it to shape. Locate the center of the guard screw holes at each and drill a very small hole at these points—just large enough so that a small brad can be inserted. Now try this templet in the original stock, note the inaccuracies, and carefully file where necessary until it will enter the mortice easily. Then go round the edges and carefully file templet about 1/64 inch smaller all round.

Clamp the stock blank upside down in the vise, and with the marking gauge mark a center line along its entire lower edge, then carry this line round both ends and continue along the entire top edge. The top edge should of course have been previously planed to a straight line, and if the blank happens to be warped, it should be straightened in planer or jointer, otherwise the center line will not be straight. If you expect to provide the stock with a cheek piece, the line may be run off center to the right, to allow the maximum thickness of wood for cheek piece. It should not however, be less than 1 inch from right side.

Now, with the stock held as in Figure 80, place your magazine templet in position, so that the center line of stock shows through the small hole in each end of templet. Fasten in place with a brad driven through each hole, and mark carefully round templet with a sharp awl or scriber. Before removing templet, retrace the scribed line with a sharp pointed pencil to show it more clearly. The rear end of templet should be located in relation to the pistol grip so that grip is about 1/4 inch forward of where you want it in the finished stock—this to give you a little working leeway.

Remove the templet, and hang it up until the next job. With a try square mark a line across the stock at each of the brad holes.

Continue the forward line up both sides of the stock, squaring from top edge. Lay the blank along side the original stock, and with try square and sharp pencil mark cross lines where each shoulder appears in the original. Now set the blank straight up in the vise, and with a 7/8 inch augur bit bore a string of holes through the portion where the magazine is to be let in. If this is your first job, better use a 3/4 inch bit to play safe—it just means a bit more chisel work, but it is safer, in case the bit should run a trifle sideways. Bore until only the point of bit comes through the wood,

Fig. 80

and then finish from the other side. If the point is missing the center line you can center it from the other side, and possibly avoid trouble.

INLETTING: At the forward end, where the brad holding the templet was driven in, drill clear through with a 1/2 inch augur bit, centering the spur in the brad hole. Now take a steel straight edge or ruler, and a very sharp, thin bladed knife, and cut down deeply along all the straight lines, turning the point of knife a trifle toward the center, and using care not to enlarge your outline. Use a 1/8 inch Number 9 or 10 Addis chisel for cutting the round corners of the magazine mortice, and a 3/8 inch Number 8, 9, or 10 for cutting around the extreme ends. (See Chapter 3). Make these cuts of the outline about 1/8 inch deep then remove the wood by cross-cutting with a very shallow gouge, such as a 7/16 inch

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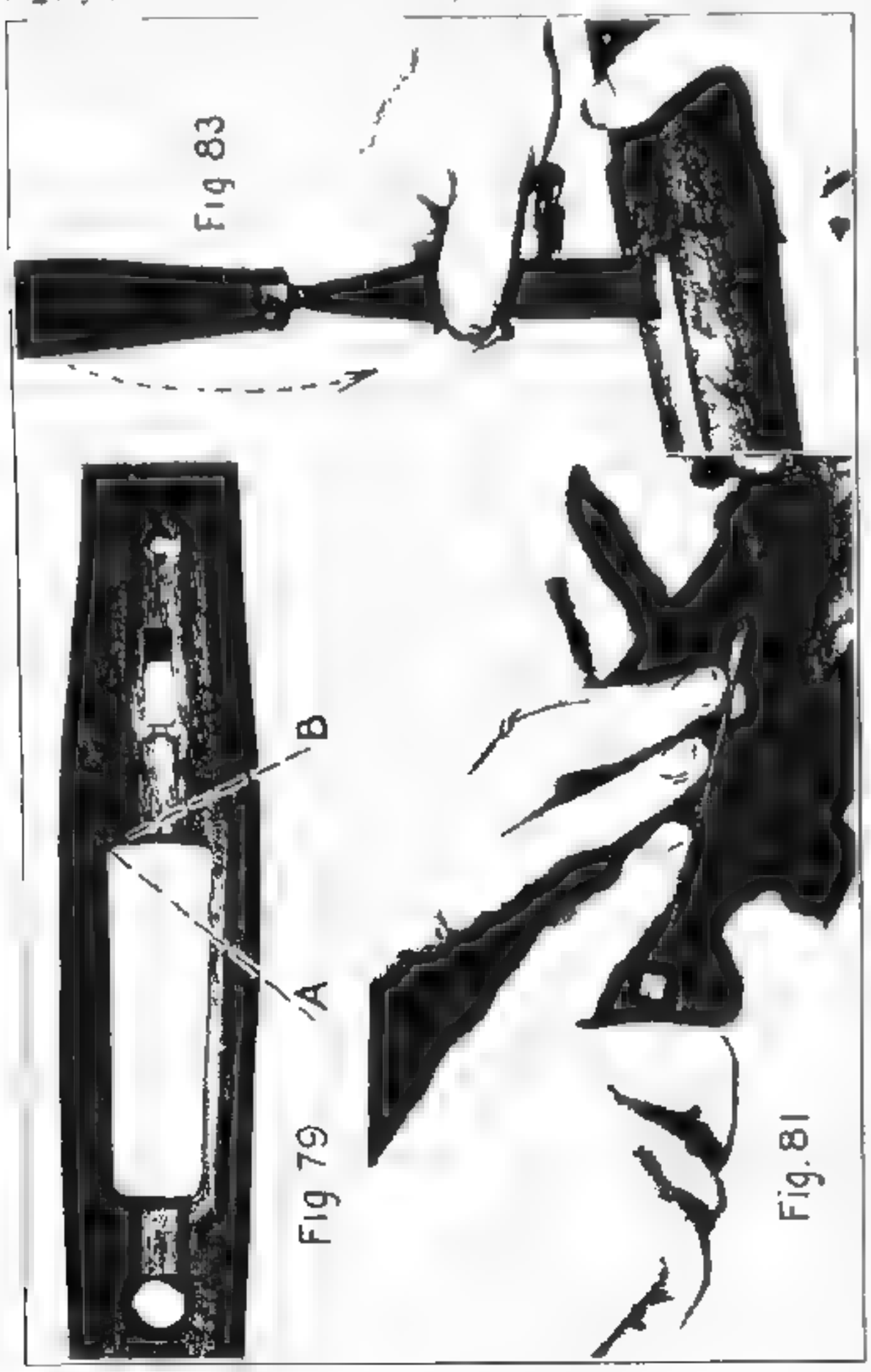
Number 5 or 6 Addis Chisel. Figure 81 shows the method of cross-cutting from center toward each side, to avoid any splitting or tearing, no matter how curly or cross-grained the wood. All inside cuts are much more easily made across the grain, but the tools must be kept very sharp, so as to really cut, and not merely "dig," "gouge," or "tear." This cross cutting leaves a ridge in the center which is removed with a 1/2 inch flat chisel at first, and later, as the cuts are deepened, the bottoming tools described in Chapter 4 will come into use. They are especially necessary in the end next the grip, where the chisels cannot be held at the proper angle.

Having removed the wood to a depth of 1/8 inch or so inside the outline, the next step is to let in the magazine. Use a wide, very slightly curved chisel for this. A 7/8 inch or 1 inch Number 3 or



4 Addis Chisel is almost indispensable for this work. If you have nothing but a plain carpenter's chisel, the cutting edge should be ground and whetted to a slight curve. Push the chisel straight through until the sides are straightened up and the magazine will start to enter. Now coat the entire surface of magazine and under side of guard with lampblack and oil, using a stiff bristle brush and applying the thinnest possible coat. Try the guard, forcing it in as far as possible without driving it. The black smudges will show you the high spots which must be taken off. Trim them slowly and carefully, always across the grain, and always with a very slightly curved chisel rather than a perfectly flat one. Re-blacken the magazine and try it after every few cuts, and as it approaches its final seat, take the lightest possible cuts to avoid leaving gaps. When fully seated the outer surface of guard will be perhaps 1/8 inch below the surface of the wood— the blank should be sufficiently oversize for that.

IMPORTANT: When fitting the guard, the edges of tang portions must be tight against the wood. This of course will blacken the wood each time it is tried. So long as it can be seated with moderate pressure, do not keep cutting away the wood at the sides, or wide, unsightly gaps will result. Remove only the wood where it actually prevents the parts entering.

Compare your work as it proceeds with the machine cuts in the original stock. Many points will be noted where you can leave in extra wood, providing additional support to the steel. Work slowly and fit as closely as possible at all points, particularly where the wood and steel join at the outer edges, where gaps will be most unsightly. Be sure the magazine goes in straight—not canted to either side. If the thickness of the blank necessitates sinking the guard much below the surface, the surplus wood should be trimmed from the outside. Use a wide, slightly hollow chisel for this. Rest it on the surface of guard tangs and cut toward the sides, but do not bring the wood closer than 1/16 inch from the surface of steel until ready to shape up the stock.

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All of this work with the chisels has been done by merely pushing the tool with the hands. The only place where a hammer or mallet may be needed is for cutting straight down through the wood at either end. The commonly accepted method of "chiseling"—striking the chisel with blows of a hammer or mallet—has no place in stock making. Hold handle of chisel in right hand and push it with a firm, steady motion, making short, light cuts. Rest the left wrist or forearm on the work, and use the first and second fingers of left hand to guide the chisel point, resting the fingers firmly on blade, but without heavy pressure.

The guard and magazine should be fitted sufficiently tight that a smart blow with heel of hand is needed to seat it to its depth. To remove it, hook the forefinger in the guard and tap the wood around it with a hammer. Eventually you will free it up a bit to a slightly looser fit—but leave it tight for the present

Having inletted the guard and magazine, the barrel and receiver come next. The easiest way, and the most practical way in large shops, is to have the barrel out of the receiver, and fit the receiver alone first. However, since the majority of readers will desire to fit the two together, we shall consider that method first.

It will be remembered that when fitting in the guard we bored a 1/2 inch hole clear through the blank at front end of guard—this to accommodate the projection through which the front guard screw passes. Probably this hole had to be trimmed out a bit with the chisel as the guard was bedded.

Secure a piece of iron or mild steel rod just large enough to slip through front guard screw hole, and thread one end for a half inch so that it may be screwed into guard screw hole in forward end of receiver.

Clamp the blank in the vise right side up, and with magazine and guard fitted in snugly. Insert this rod, previously screwed into receiver, from the top down through guard screw hole in guard Thus the parts are held in their proper relation to each other, while the guard and barrel rest upon the top edge of stock blank, with only the recoil lug and the rearward projections on underside of receiver touching the wood. Mark around these with a pencil, and rough out the wood beneath them with a hollow chisel or gouge, until the receiver and barrel are resting on the wood. Now mark around both barrel and receiver, turning the pencil point inward,

always keeping the outlines smaller than the parts being fitted. Again rough out some wood, until the barrel and receiver are settled, a little way into the blank, making sure that both barrel and receiver tang are centered on center line of stock. Now remove barrel and receiver, and coat underside at all points with the lampblack and oil. Settle back into place in the stock,—always leaving the rod screwed into receiver to guide it to exact location; press down firmly, and note the points where black spots are left. Cut away the wood

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at these points, selecting the chisel that fits best, and cutting across the grain wherever possible. Use a 9/16 inch Number 9 Addis chisel to rough out the barrel channel—this will of course have to be cut with the grain. Cut right up to the outlines until the barrel is resting down tightly against the edges of the wood. Keep working out the receiver mortice at the same time, so that the whole assembly is kept level as it settles. When the barrel is bedded about 1/8 inch less than half of its diameter, you may outline it carefully—and the receiver also—with a very sharp scriber or point of a knife. Be sure to turn the point slightly inward, keeping the outlines a bit narrower than the parts. Now remove barrel and receiver, and work out the barrel channel the full width of the outline, carefully cutting to the exact center of the knife or scriber line. Study the grain of the wood constantly, so as not to cut against it, possibly splintering or tearing beyond the lines. Use a small steel try-square, or any piece of steel having a right angle corner, to gauge the depth of the channel. Figure 82 illustrates the method of depth-gauging half round grooves known to all pattern makers. With the blade and head resting on the edges, the corner will just touch the bottom of groove when the right depth is reached; moreover, when the groove is true and round, the corner of square will touch at any point on the inner surface ("b," Figure 82).

A templet like Figure 26A (Chapter 4) may be conveniently used for gauging the depth of receiver cut at its extreme front end. This is made of sheet brass, being one half of a 1 1/4 inch circle. By cutting clear down at once at this point, you have a convenient guide for many of the other cuts.

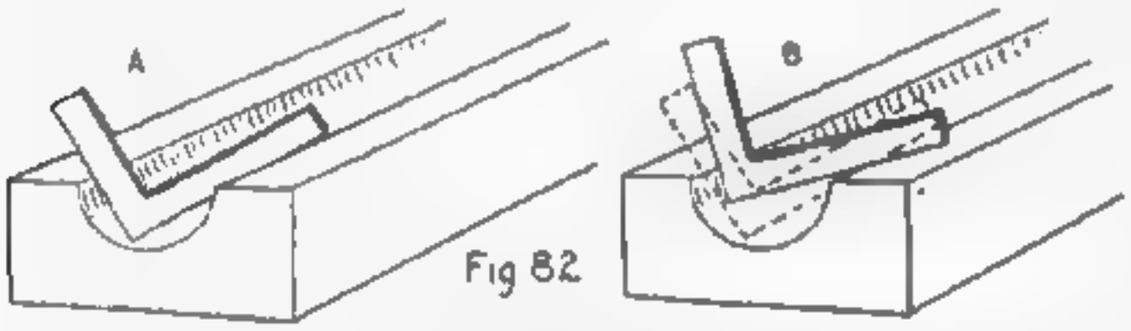

Fig 82

Now, having cut the barrel channel out to a true half circle, you are ready for the final fitting. The channel will be slightly narrower than the barrel, due to the scriber point having been turned slightly inward when the outline was marked. Thus the barrel is resting not quite half its depth in the channel. Work away the edges with extreme care, taking off the thinnest shaving imaginable, at the same time working out wood as needed in the receiver mortice. Finally, the barrel will be resting on the bottom of channel, but is not seated to quite half its depth, because our original outlines were a bit narrower than the barrel. The wide, nearly flat chisel now comes into play—and for this use it is worth its weight in

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gold. This may be a 7/8 or 1 inch Number 3 or 4 Addis, or it may be a common 1 inch socket firmer chisel such as carpenters use, with the end ground to a very slight curve. Hold it as shown in Figure 83, and starting at the extreme edge, cut toward and slightly past the center of bottom of channel, meanwhile rocking the handle outward as indicated by dotted arrow. The cuts thus made should be very shallow, overlapping each other slightly, and scarcely more than scraping off the surface. The chisel must be honed and stropped until it will shave the hair from the back of your hand. (See instructions for sharpening and care of chisels in Chapter 7).

Coat the barrel with lampblack and try it frequently. When the channel is opened up so that you get black smudges on bottom and both edges, remove no more wood from the edges—keep them tight against the barrel from now on—and deepen channel only in the center until the *entire surface* of channel from edge shows the impression of the lampblack.

Toward the last the final deepening may be done, and the tool marks removed with No. 1/2 sand or garnet paper wrapped about a round stick. Extreme care must be observed not to rub the sandpaper against the edges,—just a stroke or two will leave ugly gaps.

All the while you have been thus bedding the barrel, you have also been cutting away wood in the receiver mortice as indicated by the black smudges, bedding it at the same time. When the barrel is down nearly half its diameter, you can remove the rod which is screwed into the receiver, and substitute therefor the short forward guard screw. Set this screw up snugly each time you try the barrel for fit, using the screw to draw the receiver and magazine together. A little later, when almost, but not quite the full depth has been reached, drill the hole for the rear guard screw

This can be a very easy job, or a very difficult one, according to the way you go about it. The receiver tang, being "blind" on the upper side, the first thing is to locate the center of the hole. Coat under side of tang rather thickly with lampblack and press it hard against the wood, leaving the screw hole outlined thereon in black. Center this carefully with dividers and prick-punch the center. If you have a lathe, put a 60° center in the tail-stock; chuck a drill the same size as the guard-screw bushing in the headstock; on under side of stock blank mark the position of rear guard screw hole with awl or scriber, and center it with dividers. Now hold the blank between the lathe center and drill point, so that the center in tail-stock of lathe is pressing into the punch mark in top of stock, and the drill point into mark in under side. Run the lathe slowly, using the handfeed on tail-stock to force the wood against the drill until you feel drill meet the point of the dead center. Remove, and finish the hole with handdrill. Thus, the hole is absolutely lined up to register with screw holes in guard and tang. This is particularly difficult when using a brace or breast

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drill on the "b'guess and b'gosh" system, as the screw takes a very slight angle forward, which is hard to control. If necessary to drill it by hand without guides, drill from both sides using a drill smaller than the required hole, and finishing it out to size with a small rat tail file.

If the shop makes a good many stocks, the drilling jig described in Chapter 4 will be found indispensable, for drilling for guard-screws, stock-screws, and many other purposes.

With both guard screws in place and set up tightly, you can see just how much more cutting must be done in the stock. When both magazine and barrel and receiver are fully seated, the upper edges of magazine should just touch the bottom of receiver, with lip at rear of magazine seated smoothly in place against rear end of magazine cut in receiver. Usually it will be found necessary to inlet the magazine a trifle deeper to bring it to final position, but this should not be done until barrel and receiver are seated to full depth,—half the diameter of the barrel. The projecting portion on left of receiver where cutoff is located must be carefully fitted—its recess being considerably deeper than it is in the service stock. Keep the upper edge of stock on left side in a straight line from forend tip to extreme rear of cutoff—this looks much better than to slope it off at front end of receiver, as many factory stocks are made. Even up the bearing surfaces in receiver mortice, so there is no rock or wobble at any point.

Now, when you think everything is fully seated, set the guard screws up tightly, and look at the tip of forend. Quite likely there will be a gap of a sixteenth inch under the barrel at this point. Sandpaper lightly the entire inside of barrel channel and receiver mortice to clean it up, then coat barrel and receiver again with lampblack and seat carefully, drawing up the screws again. Note the points near breech of barrel and front end of receiver which must be cut down a trifle more. Work them down until pressure there is very light, and quite firm at tip of forend as indicated by the black smudges. The inside work on the stock is then finished except for a very slight dressing out along the walls and at rear of magazine to relieve pressure.

Figure 84 shows a stripped receiver being inletted without the barrel. It is much easier and faster to inlet the receiver alone, and shops doing a considerable amount of stocking on any one model of gun should have a spare receiver kept for this purpose. When the receiver is fully inletted, then the barrel and receiver together are put in place, the forward end of receiver being raised and the barrel resting on the wood. The barrel is gradually bedded by

cutting out the wood from receiver forward, all work in barrel channel being done in the same manner as already described.

This method of first inletting the receiver without the barrel can be adopted by the man who is having a special barrel fitted to his

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receiver. After the receiver is inletted it is sent to the barrel maker, then, when returned with the new barrel fitted, the latter is bedded in the stock as described.

The foregoing instructions apply to what may be termed fully bedded barrels. This method is usually followed on high grade custom built hunting rifles. The point of greatest pressure between barrel and forend should be at the bottom of forend tip, but light pressure should be maintained at all points. The upper edges should be tight against the barrel, with equal pressure on both sides. This method is quite satisfactory unless the condition of the wood makes

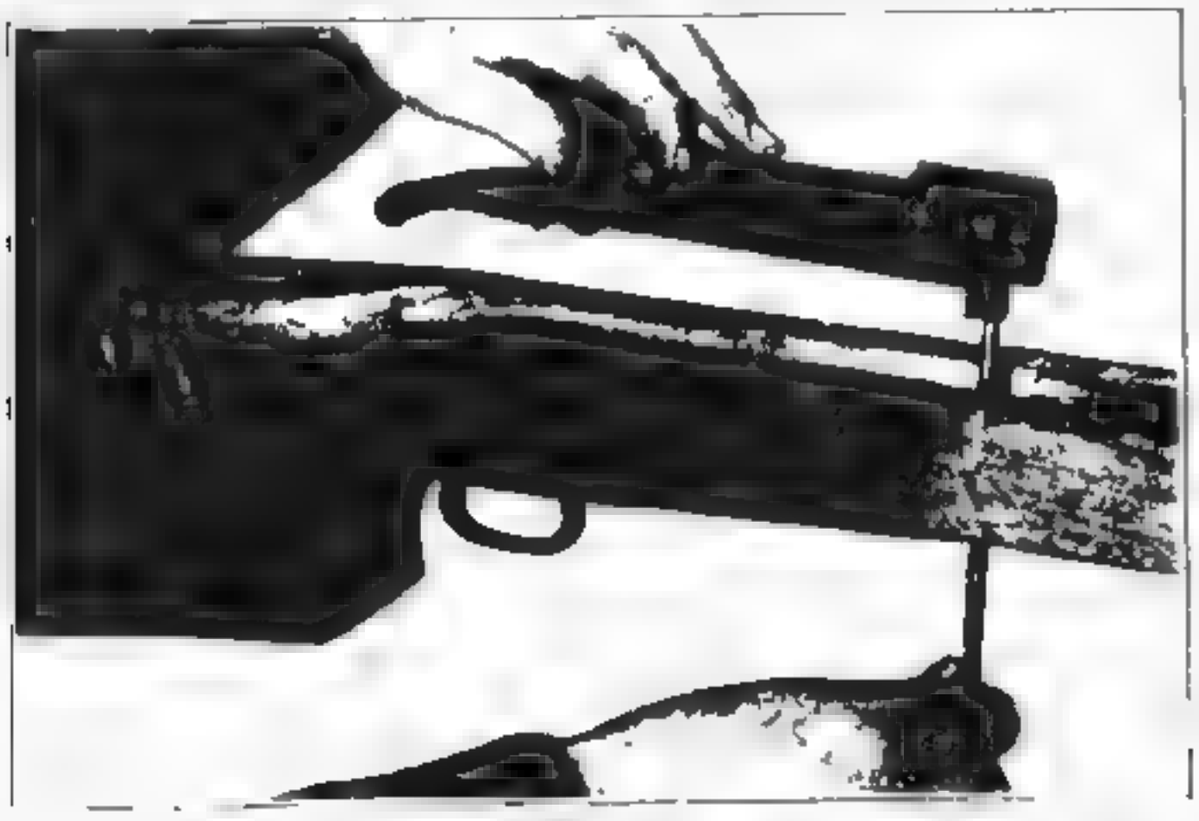

Fig 84

it likely that the forend may sometime warp and develop undue pressure against one side of barrel—and if the barrel is of the pipe-stem variety, the point of impact will be changed thereby.

This may usually be guarded against in very light barrels by the semi-floating system of inletting. The barrel is bedded tight as above described, then the wood is shaved out all round except at the upper edges and at the tip of forend, so that there is about 1/16 inch clearance at all points but these. These points are then relieved by lightly sandpapering until they are just clear of the barrel so that a sheet of thin paper may be slipped between barrel and forend. This much clearance is scarcely noticeable, and allows for slight warping of the wood due to atmospheric conditions, dampness, etc.

Examples of the full floating barrel are found in many military rifles—the Springfield service rifle, the Lee Enfield, Ross, and per-

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haps others. Here the barrel is left entirely free from the wood, touching nowhere. The handguard and forend are bound together by two or more bands, and the barrel has clearance of at least 1/32 inch all round at the muzzle. I believe Captain Crossman's old favorite target Springfield by Wundhammer is stocked in this manner—the band encircling both forend and handguard, and the barrel entirely free from contact with the wood.

Having successfully inletted one or more Springfield stocks, the beginner will have acquired experience enabling him to do a good job on any bolt action arm. The essentials are the same in any case, with a few minor differences which will be briefly discussed.

On the Mauser, the rear guard screw usually sets in from the top of the receiver tang, and is at right angles to the bore, making it somewhat easier to bore the hole for this screw than the Springfield. The Mauser, moreover, has fewer projections and irregularities on the receiver than almost any other, and is somewhat more easily inletted for that reason. The receiver tang is narrower and more tapering, moreover its rear end does not enter the wood quite so deeply, which increases the danger of its splitting the stock. When stocking any Mauser having more recoil than the .30-06, or weighing less than 7 3/4 pounds, it is advisable to use at least one stock screw, placing it in such a position that the recoil lug of receiver bears directly against the screw. The ends of stock screws may be concealed, if desired, by the methods described elsewhere. (Page 145).

The 54 Winchester is quite similar to the Springfield, but the receiver is simpler in outline. The square portion on under side runs in a straight line from tang to barrel ring, making a very simple mortice. The magazine is separate from the guard, fitting tightly into the receiver. It should be driven out and the barrel and receiver may if desired be inletted before the magazine cut is made. The guard and floor plate being separate from magazine, may be used as a templet for itself. After receiver is inletted, bore and cut out the magazine mortice from the top side, then the magazine may be driven back into receiver.

The Model 30 Remington, along with its daddy, the Model 17 Enfield, is considerably more complicated than either the Springfield, Mauser or Winchester, when it comes to inletting. There are no special instructions, however,—simply study the original stock mortices carefully, and follow the rule to remove as little wood as possible, giving maximum support wherever you can.

The various .22 caliber bolt actions, such as the 52, 56 and 57 Winchester, and the Savage Models 1919 and '23 sporter series, are all quite simple, since the receiver is practically cylindrical—the Savage receiver being merely a continuation of the barrel, the whole assembly being bedded in a half round groove in top of stock. On these rifles the barrel and receiver may also be inletted first, then the guard screw holes and magazine well are located and cut

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from the top, after which the guard is fitted. On the Winchester there is a hole in the side of stock over the magazine, through which the magazine catch operates. This hole should be located by carefully measuring the distance from bottom edge of stock to its center, and the distance back from front end of receiver. Bore this hole undersize, then work it out carefully with sharp rattail file and hollow chisel until the magazine catch bushing nut will just fit snugly.

The Model 5 Ross also has a receiver nearly cylindrical, and is very easy to inlet, the barrel and receiver being inletted first, then the guard, after the magazine has been removed from it, will form a self-templet like that of the 54 Winchester. The guard screws are used to draw the parts together as the inletting proceeds.

The peculiar construction of the Krag necessitates certain changes in the usual procedure. The first cut to make before doing anything else is the rectangular recess for the magazine. Lay your blank with the left side up on the bench; lay the original stock on top of it, and outline this recess with a sharp pencil. Saw and chip out the wood, keeping about 1/4 inch inside this outline, then with chisels carefully enlarge the recess until the magazine will start in. Spotting frequently with lampblack as previously described, gradually work out excess wood and let the magazine in deeper, until tang and barrel are resting on upper surface of stock. Now mark your outlines all round, turning the pencil point well in; rough out surplus wood, then continue spotting and fitting slowly and carefully until all parts are fully seated, studying the shape in the original stock constantly.

The Krag has no recoil lug, the square rear end of magazine acting in that capacity. It is important therefore, to keep the wood very full here and fit it up tightly against the back of magazine.

The guard-screw holes are located from the inside by coating under side of receiver thickly with lampblack, and drilling in the center of the impressions thus left. Lay the guard in position over the holes, outline it with a knife point, cut the outlines and remove excess wood, and draw in the guard as fitting proceeds by tightening up the guard screws.

The 7.62 mm. Russian is one of the meanest of all to inlet. The long, narrow guard and magazine is very easily thrown out of alignment, and the shape of the sides is difficult to cut into the wood. Make a templet for it by taking a paper impression of the old stock, as described for the Springfield. These templets should be made for all jobs where the magazine and guard are in one piece, like the Springfield, Mauser, etc., but are not necessary on guns having the guard and magazine separate. As a general rule, all actions of the Mauser type should have the magazine inletted first, and on others, with guard and magazine separate, the barrel and receiver should come first.

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CONCEALING STOCK SCREWS: When it is necessary to

use stock screws as a safeguard against splitting from recoil, or when putting in a screw in repairing a broken stock, or for any other reason, the screw may be concealed by inlaying a piece of wood, ivory, bakelite, horn, ebony, or other material. The inlay is first cut and filed to the shape desired—a diamond, circle, etc., and its edges slightly beveled on the under side. If the inlay is used to cover stock screws, the screws should be cut short enough so both ends are about 1/8 inch below the surface of the wood. The inlay is then held over the hole, and its outline marked out with a sharp knife. Cut the outlines deeper with a thin bladed, very sharp chisel, and carefully trim out the wood. Press the inlay into place, noting where the edges must be trimmed to fit. When finally fitted, cement in place with Du Pont Cement, and hold in place for 48 hours by clamping in a vise. Use a piece of felt or soft leather to prevent breaking, and be sure the inlays are held flat against bottom of recesses. These inlays should be made thicker than required, then filed and sanded off flush when the cement is dry.

Another way of hiding screwheads which is known to expert cabinet makers, is as follows: Before drilling the screw hole, take a thin and very sharp flat chisel 1/2 inch wide, and after wetting the surface of wood to soften it, cut a shaving about 1/16 inch thick and 3/4 inch long, leaving one end attached. Wet or steam this shaving so it may be turned back out of the way without breaking off, then bore the hole and set in the screw at the desired point. Hot glue or cement is now applied and the shaving glued back in place, with a piece of blotting paper over it, and firmly clamped. When the glue is hard, sand the spot smooth and clean, and if the cut was made with a sharp tool which did not bruise the edges, it will be invisible.

Having inletted the magazine and the barrel and receiver, and brought them together to the proper fit, take a sharp pencil and mark out the trigger cuts from the opening in bottom of receiver. Drill through with a small drill or augur bit, making several holes as required, then cut out the space between them with a 1/4 inch chisel, following the lines of the cuts in the original stock, but leaving in wood wherever you think you can. Now fit the trigger, sear, and other small parts into the receiver, and try it in the stock. Coat the trigger mechanism with lampblack and oil, and the spots where more wood must be cut out will be clearly indicated. Replace the cutoff, or bolt release, if it was previously stripped from receiver, and likely a few cuts will be needed to make it work freely. When you are satisfied that the job of inletting is complete—that each part is fitted as perfectly as may be, and when the bolt and all other parts work freely, the rifle is ready for its first "shootin' in."

"SHOOTIN' IN" THE STOCK: Tighten up the guard screws. If your fitting is right they should set up very tightly due

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to pressure of the wood, before stopped by the bottom of holes in the receiver. With a little practice one can learn to tell when the screws are in their full depth. If being stopped by the points touching the bottom of the holes, it is well to grind off about one thread, to provide a little more take-up for tightening. Having set them as tightly as possible, take the gun out behind the barn, or any place where the neighbors won't object, and fire twenty or thirty of the heaviest loads you will ever use through it, holding the butt against something solid such as a tree or stump. If the stock is ever going to split from setback or recoil, you want it to do so now, before any more precious hours have been expended on it—so give it the works. Split it if you can.

The stock having passed successfully through this ordeal, and your anxious gaze having discovered no evidences of faulty fitting, you are now ready to shape it up. This is one of the bright spots in the stocker's somewhat sordid existence. Now you can see your work begin to take shape under the tools—you really feel that something is being accomplished,—and your dreams of a stock "just for you only"—a stock that fits you to a frog hair is about to be realized.

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Chapter 11

STOCKMAKING: SHAPING AND FINISHING

IN shaping up a stock I like to start at the forend and work right on back. This is as good a place as any to describe the method of ATTACHING A FOREND TIP, so we'll begin with that.

Figure 85 shows the blank with tip of buffalo horn, ivory, ebony or what have you, clamped into place with the home-made C-clamp described in Chapter 4, while Figure 86 shows how the tip was prepared before fitting. Make the dowel of a piece of 3/8 inch hardwood dowel rod cut about 2 1/4 inches long. This plug

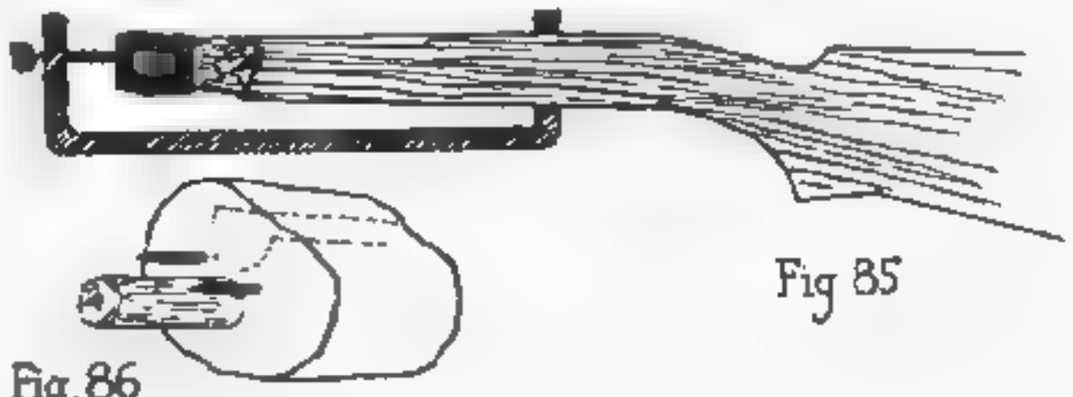

Fig 85

Fig. 86

should be sanded to a smooth, snug, but not tight fit in the hole in horn, which hole should be drilled with a twist drill to a depth of about an inch, or more, depending on the length of the horn. The steel pins are not to be put in yet.

Saw the forend off square at the length desired, preferably in a mitre box—this to be done before any shaping. Drill the dowel hole in it directly under center of barrel channel, so that it comes about 1/8 to 3/16 below bottom of channel. Now remove the dowel from the tip, coat the tip with lampblack and oil, replace

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the dowel, and push it into the hole in forend until the surface of tip touches the wood. Work the horn about slightly to rub the black against the wood, then remove and note the spots of contact. Work them off carefully with a medium cut file, again coat the horn with black, and fit again. Continue until there is perfectly even contact of the two surfaces—horn and wood—*at all points*. In some forms of glued joints, it is permissible to have perfect contact only at the outer edges. Not so in this case—for the reason that we don't know yet just where the outer surface of our forend will be. Absolutely perfect contact over the entire surface is what we require here, and nothing else will do.

When the wood and horn are fitted together so there is no gap anywhere, wipe off the lampblack and scrape the horn to remove every bit of oil or grease. Also scrape the end of the wood clean. Drill holes as indicated which will be a tight fit for two six penny nails. Keep the holes in fairly close to the dowel, so there will be no possibility of cutting into the nails in dressing down the tip. Drive the nails into the horn, cut off the heads and sharpen the projecting ends with a file. These should be about 1/2 to 5/8 inch long. Fit the tip into place on forend and mark where the points of nails strike the wood, and drill two holes so they will enter readily. Now melt up some white flake glue and let is simmer at just below boiling point. Remove the dowel from the horn and apply glue into the hole over the surface of the horn, and in the dowel hole and on surface of wood. Also coat the projecting end of dowel with the glue. Work fast while the glue is hot. Seat the tip firmly with a blow of a mallet, then clamp tightly as shown for 48 hours. The joint will then be firm and solid, and the groove for the barrel may be cut with chisels, just as it was cut in the forend. Be careful!—this horn sure is death on chisels.

Now for THE SHAPING. The only tool you will use for a while will be the half-round cabinet rasp, which should be 12 inches long for convenience in handling. Clear the bench of all other tools and parts, so that nothing will be lost in the filings. Keep a picture of a gun having the kind of tip you want before you, and study it at frequent intervals. First round off the end of horn tip, from top to bottom, then from side to side, and make it the shape you want, while bringing it almost to finish size. Leave the upper edges square along the barrel channel.

Continue the rasp work back into the wood an inch or so, then stop work on this end and move back to the portion over the magazine. Here the Prentiss No. 19 vise proves invaluable, for the swivel jaw enables you to hold the stock on its side, the jaws gripping upper and lower edges of buttstock, while the swivel base enables it to be swung about as desired and locked in any convenient position. Shape the sides of stock as desired over the magazine mortice—

either oval or flat—using the round side of the rasp to rough off

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the surplus wood, then the flat side for the final shaping. Allow about 1/16 inch extra thickness all over for finishing. Now turn the stock top edge up, and with a sharp black pencil draw a line from the upper edge you have established over the magazine, forward to the edge established at the forend tip, using a straightedge. (See Figure 87) Clamp the stock sideways in the vise again, and rasp the forend down to this line, working across the grain always, and *against* the square upper edge, to avoid slivering. For the present, regardless of its final shape, leave the bottom of forend very much wider than the top. Work down both sides of forend in this manner, then turn stock bottom edge up in vise, clamping it about the grip portion.

The original center line you marked on the stock blank still shows. Blacken it with a lead pencil to bring it out clearly. Draw lines

Fig. 87

running in the same direction but closer together at the tip of forend, to establish the taper, then rough off the wood to these lines. The forend may now be rounded up and shaped as desired, using the flat side of rasp for most of the work.

The stock is now shaped in the rough from forend tip almost back to the grip. The next question to be decided is, shall the stock have A CHEEK PIECE, and shall it have CASTOFF? Assuming that it is to be cast off, first measure and mark the desired length from center of trigger to center of butt; draw a line for approximately the desired pitch, and saw off the butt, allowing about 1/4 inch extra length. Remark the original center line on butt, then establish a new center for the castoff as explained in Chapter 9. (See Figures 46 and 48, Chapter 9). Now make a brass templet the shape of buttplate to be used, and 1/8 inch larger all round, notching the center of templet at both ends. Center it on the castoff line on butt and mark round it. Now set the stock in vise as shown in Figure 34 (Chapter 7) decide on the shape and position of cheek piece, and sketch its outline in pencil. Cut round it with a hollow chisel as shown in Figure 34, making the cut deeper toward bottom of stock. When about 1/4 inch deep, start shaping this side of stock with rasp, using the round side to speed the work, and

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working from rear of cheek piece back toward the butt outline. For the present leave the butt its full length from heel to toe, making no attempt to establish the drop.

The surplus wood directly below bottom of cheek piece can be roughed out with hollow chisel.

Now turn the stock over and rough off the surplus wood on right side of buttstock, leaving it very full all over. The best way to hold the stock while working on butt is to lay a round tapered stick of hardwood, such as a piece of broomstick or a chair rung in the barrel channel, and hold the stock sideways by the forend, the jaw of vise pressing against this stick, which must be slightly smaller than the barrel channel, so as not to split it. For the present do not rasp the stock nearer than 1/4 inch of its final thickness.

Next comes THE GRIP. With dividers measure carefully the required distance from the trigger to where the front edge of grip is to be located; mark the bottom line of grip, and saw to this line. Dress the end off square and smooth with a flat wood file, then replace the center line which was sawed off. If you use a metal or horn grip cap, place this in the required position and mark its outline. If not using a cap, then a paper pattern should be made the desired oval shape, and pasted on. Now, using the round side of the rasp, round off the forward edge of pistol grip, then work down the sides, but leaving the grip at least 1/8 inch thicker all over than it is to be when finished. Next file down the comb slowly and carefully, so that when the bolt is drawn fully to the rear the sear notch on cocking piece drags heavily over it. Round off upper edge of stock, and thin the sides of comb and upper part of cheek piece just enough to enable you to see through the sights, and the rifle is READY TO BE SIGHTED IN. Instructions for fitting and aligning sights are fully covered in Chapter 29.

When the barrel and receiver were inletted, probably everything was stripped from the receiver. If you use a Lyman 48 or any other receiver sight, it should not be fitted until the stock has been fully inletted. Then, after sight is attached to receiver, as explained in Chapter 29, set the action as far as it will go into the stock, and mark the position of the sight base on side of stock with a sharp knife. Take a coping saw or scroll saw blade (using the blade only, without the saw frame,) and reverse ends with the blade so it cuts as you pull it toward you. Using it thus, cut down about a quarter inch into the wood at front and rear of sight base, and carefully remove the wood between the cuts with a 1/2 inch flat chisel. Coat bottom of sight base with lampblack and oil, and press down into stock. Take off the wood slowly, so as not to make the notch too deep. The cut should be deep enough, however so that the wood does not quite touch the sight base, as the strain would tend to loosen the screws. There should also be 1/32 inch clearance between the back of sight base and the wood, for there is very little wood at this point, and

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any back thrust that might develop would easily split off a piece.

Having sighted in the rifle for the desired range, and set the sights firmly, the line is established for measuring the drop of stock. Usually the range for sighting in is 100 yards.

Set the rifle right side up in the vise, and attach a heavy thread to the tip of front sight, by winding a heavy rubber band around it. Run this thread through the smallest aperture of the peep sight, and draw it taut, keeping the thread not touching the rim of aperture at any point. With the rasp work down the heel until its vertical distance from the thread is about 1/16 inch less than the required drop. In like manner, work down the comb—or, if you want the comb as high as bolt will permit, keep it as it is, with the cocking piece just dragging. Now rasp the upper edge of stock between heel and comb to a straight line, and immediately replace the center line on the new surface.

If the stock is castoff, you need not replace the original center line, but draw a line from the heel castoff at butt, forward along the top of stock until it intersects the original center at rear of tang (Line b—b—b, Figure 48, Chapter 9). Draw a similar line on bottom of stock from the castoff point on toe of butt, intersecting original center line back of trigger guard.

FITTING BUTTPLATE. The buttplate or recoil pad is to be fitted next. Assuming that you will use a steel shotgun type butt plate, or one of the Mannlicher-Schoenauer type, proceed as follows: First, remove the trap and spring, if the buttplate has a trap. Hold plate in position on butt so that the center line, or the castoff center shows exactly in center of screw holes in buttplate. The lip at heel of plate should come just below the surface of upper edge of wood at heel. Mark the outline of plate carefully on butt, and *with the* rasp bevel off the stock all round almost to this line. Now rasp the butt to a slight curve toward the middle, working down the edges first, and replacing the center line as fast as it is worked off. Start the notch for the lip of buttplate, but deepen it very slowly as you proceed. For this notch select hollow chisels which fit the curve, and cut straight in along the outline, removing the wood between outlines with a 1/4 inch flat chisel. Coat entire undersurface of plate with lampblack and oil, and press into place. Most of the fitting can be done with rasp and half-round wood file. Sometimes it will be found convenient to use a wide flat chisel with very slight curve for taking off the high spots. Work down the butt until the entire outline is in perfect contact all round, when the plate is pressed to place with the hands. Do not use the butt screws in fitting plate, for their pressure will spring the plate so as to change its curve slightly—then the trap will not fit. The screw holes should be bored only after outer edges of plate are in perfect contact all round.

Set the upper or heel screw first. Drill the hole at a slight downward angle, so the screw will draw the lip of plate down tightly.

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Turn in this screw, then center and drill the hole for the toe-screw, and set it. Ordinarily countersunk head wood screws are usually better than the regular coarse buttplate screws. The thread holds well, but being somewhat smaller, the screws can be set so that their slots stand vertically, and in line with each other. Little things, such as

keeping screw slots in line, make a big difference in the appearance of a gun, and often indicate the experience of the maker.

The screw heads, being larger and deeper than the countersink in the plate, will stick out from the surface. First loosen them three or four turns, then deepen the slot with a slotting file or hacksaw blade. Tighten them again, to be sure the slot comes well below the countersink. Then file the heads down smooth and flush with surface of plate. This makes the screws nearly invisible, only the slots showing. Later, when finishing the gun the plate and screw heads will be polished down with emery cloth, the screws carefully removed, and all parts blued

The D. C. M. Sporter buttplate is the easiest of any to attach. Merely saw the stock on a straight line, smooth up the end with a file until edges of plate touch all around, and turn in the screws.

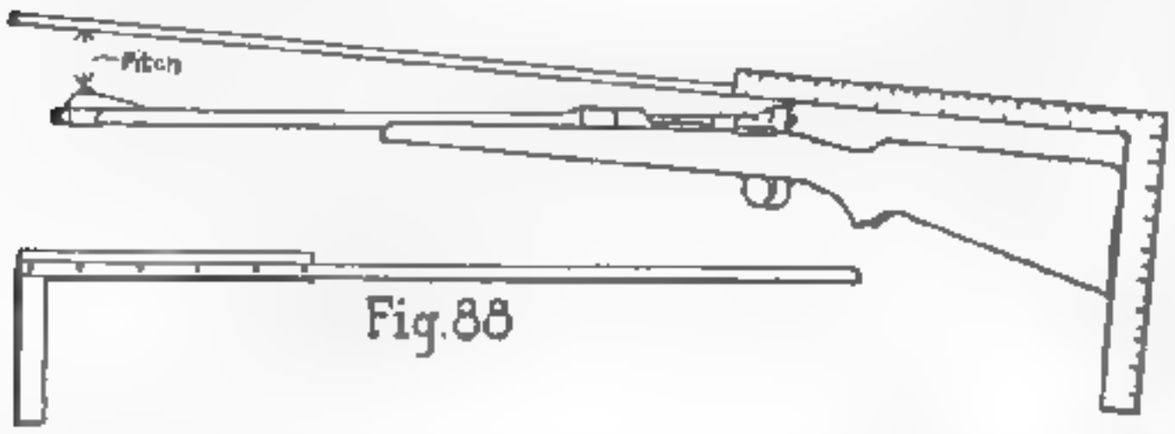

Fig.88

After fitting the plate, and before dressing down the screw heads, test the butt for PITCH. The most accurate way of doing this is to rivet or braze an extension to the long blade of a steel square, like Figure 88 which also shows this device in use. The short blade of square is held against heel and toe of butt plate, with inner edge of long blade in line with middle of rear sight aperture. The distance from end of long blade to tip of front sight indicates the pitch of butt. (See discussion of pitch in Chapter 9).

If the pitch is too great, remove the buttplate and dress off a bit of the heel of butt, setting that end of plate a trifle deeper until the required pitch is obtained. If more pitch is desired, shorten the toe. The distance from center of trigger to center of buttplate should be carefully measured while the plate is being fitted.

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RECESSING THE BUTT STOCK. Sometimes it is desired to hollow out the butt, either to lighten it and balance the rifle, or to provide a compartment for cleaning materials, if a trap buttplate is used. The recessing should be done after the stock is all shaped up, ready to sand. Hold the stock in vise, with jaws well padded, butt vertical Mark the outline of recess in buttplate, and mark centers for two or three holes, as preferred. The Mannlicher-Schoennauer plate will permit two 7/8 inch holes, and one 5/8 inch Use a sharp augur bit with single cutter lip. Center the spur carefully, and have someone stand to one side and tell you whether to raise or lower end of brace to keep the hole at the correct angle. Watch the bit as you never watched anything before, and call on your favorite household gods to keep it in the center of stock. I never yet had one run out the side but never have I bored out a butt without serious misgivings that this very thing would happen.

After boring the holes the edges should be beveled off with a knife. The wood between the holes may be removed with the "scraper gouge" described in Chanter 4, or may be left solid between the holes—the usual practice. This makes a stronger stock than if it is reduced to a mere shell, and holds more than you will want to put into it, most likely. Nothing throws a rifle out of balance so badly as a jointed steel rod and a lot of tips in the butt; I usually carry my rod in pocket or pack, with only a pull-through, a few patches, and small oil can in stock.

FITTING RECOIL PAD. The fitting of a rubber recoil pad to a new stock just being made is quite easy. First of all the butt should be sawed off on a straight line and trued up with a wood file, and the center line replaced. Now carefully work the butt down to very nearly its final shape and size, allowing not more than 1/32 inch for finishing. Set the recoil pad in place and with an awl or scriber mark the position of the two screw holes on the center line. Drill the upper hole. Next drop the pad into boiling water for a moment, to soften the base—unless this is done, turning in the screw may crack the hard rubber base. Set the upper screw in fairly snug, then insert the drill through lower screw hole and drill the hole. Set in this screw, then mark the outline of the butt on the hard rubber base, and remove the pad.

A fast running motor grinder is essential for shaping butt pads. Replace the grinding wheel with a disk of wood seven or eight inches in diameter, and on the side of wheel glue a sheet of garnet or sand paper—about number 1. Use this to dress the pad almost to the lines marked on the base. Now coat the hard rubber base with lampblack and oil, and spot it to perfect contact with the butt, just as you did the buttplate. Be careful not to press it too hard and break the base. The center surface of butt may be hollowed very slightly by scraping with a small steel scraper, to insure tight fit at edges. When the fitting is completed, put the pad in boiling water again to soften it;

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wipe it dry, and quickly coat it with du Pont Cement, also coating the butt. Put pad in place and tighten up the screws. Thick shellac may be used instead of cement if preferred, but the cement is better. It completely closes the joint and prevents dampness affecting the stock through the end grain.

The next step is to buff down the edges of pad even with the wood. This is done on the sandpaper wheel as shown in Figure 89. Work very carefully, holding the stock so that its surface is parallel with the surface of the wheel, and move stock up and down so as not to

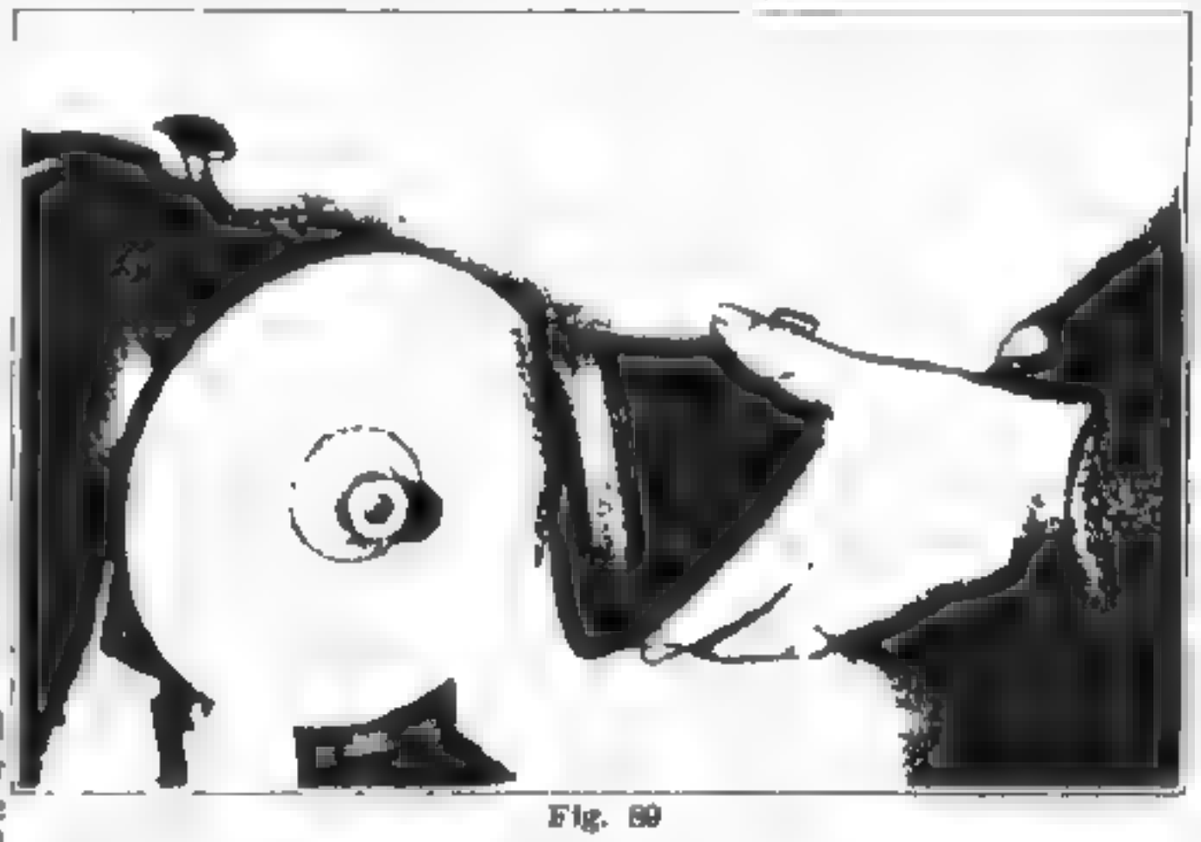

Fig. 89

cut too fast in any one place. Be especially careful when working round the toe and heel, particularly the toe. It takes steady holding and fast thinking to avoid cutting notches in the wood at these points, and also to prevent beveling the edges of the pad, which should be in continuation of the stock lines at all points. Use very light contact between the rubber and the wheel, especially when finishing the cut.

The red rubber pads with hard black rubber base are all attached in the above manner. This includes the Hawkins, the Jotsom Anti-Flinch, Hi-Gun, and the various Silvers type pads. The first three named all have variously shaped holes cut through the red rubber from side to side, to increase resiliency, while those of the Silvers type are solid, but with a hollow on the inside, which provides an air cushion. My own preference is for the Silvers type pad, particularly on rifles. Having no holes cut in the rubber, the pad is always clean and free from dirt and trash, which is bound to ac-

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cumulate in the holes. This type is slightly less resilient than the others, as it is thinner.

The thickness of the pad should be carefully measured before fitting, and the stock cut off so that it will be the right length when pad is fitted.

Of the pads having holes cut in the sides, there is little choice so far as comfort and durability is concerned. I find, however, that the Jotsom Anti-Flinch can be buffed to a smoother surface than the others. The Hawkins pad is somewhat prone to scaling on the sandpaper wheel, while the slightly tougher rubber in the Jotsom cuts much more smoothly. The Hi-Gun has the same quality of rubber, but the shape and size of the holes leaves the edges very thin, which makes it hard to finish smoothly.

There are other pads made of layers of black sponge rubber cemented between layers of soft red rubber, which are popular with shooters prone to flinch, and who stand in fear of recoil. These pads have no hard rubber base, the base being a layer of soft red sheet rubber, one end of which is cemented to the pad. To fit the pad, peel off this sheet, and tack it to the butt with the small tacks which come with it. There is also a small tube of rubber cement with which the pad is then cemented to this soft rubber base. The pad is then dressed down on the sandpaper wheel—and it isn't the easiest job to be found, either. Due to its softness, this sponge rubber is easily cut out of shape, and it is necessary to have the wheel covered with new, sharp sandpaper, and use the lighest possible pressure.

For myself I have little use for a recoil pad on a rifle, although it is a necessity on most shotguns. The man who is physically capable of going into the woods after big game, and doing a man's work about camp, certainly should be able to stand up against the recoil of the average big-game load. For with a rifle averaging eight pounds weight and stocked to fit the hunter, the recoil is almost unnoticeable. A good steel buttplate, for me, is in all ways preferable.

On rifles using any of the magnum loads, however, there is a legitimate reason for the recoil pad, as well as on very light weight rifles using a load like the .270, 7 mm., or .30-06. When the weight is reduced below 7 1/2 pounds the recoil is often unpleasant, and a good pad will often cure a bad habit of flinching.

The gunowner will often wish to fit a recoil pad to a gun he already has. The method of fitting is essentially the same as when fitting it to a stock in process of making; except that greater care must be exercised in buffing the pad down to the outlines of the stock, so as to remove as little of the original finish as possible with the sandpaper wheel.

After the pad is shaped, sandpaper the stock carefully where the wheel has touched it, letting the bare spots blend gradually into the finished portion. If the stock has an oil finish the bare spot may be obliterated by proceeding just as you would to finish a new stock,

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keeping plenty of oil on the bare spots, and wiping it off the finished portion. In time the spot will take on the same color and finish as the balance of stock. The work may be hastened by judicious use of the red oil and shellac mixture given in Chapter 13.

When the stock has been varnished, it is more difficult to repair the finish where it has been buffed off. Varnishing this spot is a mistake, for the new varnish will not have the same color as the old, and the lap is sure to show. Most gunsmiths use a mixture of about 85 parts orange shellac and 15 parts linseed oil. This is rubbed into the spot with a rag, then when dry polished lightly with pumice and oil, then another coat rubbed in and polished. Afterward, the whole butt stock is usually given a good rubbing with furniture polish.

All such methods, however, are cheap makeshifts, and should be avoided unless the owner must use the gun immediately. The only thoroughly satisfactory method is to remove the old finish completely, and refinish the entire butt stock—preferably with an oil finish.

FINAL SHAPING. But we have digressed somewhat from our subject,—that of shaping up the rifle stock in process of making. Having fitted the butt plate or recoil pad as the case may be, we are now ready to bring the stock to its final dimensions. About the only tool needed for this work is the cabinet file, which is similar to the rasp, but has finer teeth. The stock is held in the most convenient position in the vise, using the felt lined vise pads to prevent the jaws marring the wood. When gripping the stock by the forend, always use the round tapered stick in barrel channel, so that the vise-jaws do not come in contact with edges, with the ever present possibility of splitting them off.

Start in again at the forend, and work back on the stock, using the flat side of the file on all flat and convex surfaces, and the curved side only where the surface is concave. If there is considerable wood to be removed, you may use considerable pressure on the file; otherwise, use it very lightly, so as to just take off the marks left by the rasp and even up the surface. Always make the file stroke across the grain, or at least diagonally; if the file moves in line with the grain, it will shred the wood, leaving deep tooth marks which must be worked out.

Use only good sharp files. It is poor economy to keep on using a file after the teeth are blunted and worn. This applies particularly to wood files, as all wood has hard and soft spots, and a dull file will slide over the hard places without cutting, causing an uneven or ridgy

If the tip of forend is to be shaped into a snobble (See Chapter 9), the snobble outline may be formed roughly with a hollow chisel, after which it is shaped up with the round side of the wood file. Do not cut too deep a hollow back of the snobble—try to retain a streamline effect at all points.

The undercutting of the comb is also done first with a hollow

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chisel, then the lines smoothed and blended into the sides of stock with small end of file, using the round side. (See Figure 56, Chapter 9). It is impossible to describe exactly the shaping of such a comb. Study as many stocks as you can get hold of—but do not assume that all are correct. Learn to recognize their faults as well as their good points, copying only the latter in your stock.

Exercise the greatest care in shaping the sides of stock over the magazine, to get them exactly alike. Take time to study them carefully as you work. And when shaping up the portion around the tangs, it is well to have the action and barrel fitted into place. Where the tangs set into the wood, always work *against* the edges to avoid splintering. Go slow, and work the wood down almost, but not quite flush with the steel.

When you come to the grip, take your time and don't get in a hurry to see how it is going to look. If you have a grip cap, it should be fitted, and properly centered before the grip is shaped up. Outline the cap with pencil, bring it to a position where its forward edge will be the required distance from center of trigger. Mark the screw hole and drill it carefully at right angles to the surface. Be sure this hole is large enough so the screw will not split the grip. On under side of grip cap, scratch some kind of mark to show which is the front edge. After squaring up end of grip with the file, cup it very slightly with a wide, nearly flat chisel, so the edges will fit tight. Screw the cap into place, then proceed to file the grip down flush with its edges, and shape it up all over to desired shape and dimensions. Study it frequently from both top and bottom, noting any unevenness in its side contours. It is permissible, and often helpful, to leave the right side a bit fuller than the left, so as to fill the hollow in palm of hand more completely. Bring the gun to shooting position at short intervals, and try its feel in the hands.

Next comes the shaping of sides of stock, comb, cheek piece, etc. First of all, file down the flat surface of cheek piece until it feels just right as you look through the sights. Trim the edges to shape with a slightly hollow chisel (My favorite for this is a Number 7 Addis Chisel 5/8 inch wide, which gives the edge a neat inward curve), and finish it carefully with the round side of cabinet file. This curved edge narrows gradually toward upper edge of stock at both ends, until finally blending into the stock proper and disappearing. The outer edge of cheek piece should be rounded off smoothly. A small bead or square edge where cheek piece joins the body of stock is permissible, and is of assistance in retaining correct lines on the stock. (See Figure 51, Chapter 9).

The entire left side of stock should have the same lines as the right side, except for the cheek piece. It is easy to cut in too deeply around cheek piece, and it is equally easy to not go deep enough. Cut a templet from thin wood to fit the right side of stock after it is shaped up, from a point an inch below heel, reaching forward

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to base of comb. Then cut away just enough of this templet to clear the cheek piece, and use it to assure correct lines on left side of stock.

In shaping up lower edge of stock back of grip, don't leave a deep fillet. Use the square edge of a file, and carry the bottom lines right up against the grip, making the angle between butt stock and grip and clean at lower side, the grip blending into stock at its thickest part. Figure 90.

Now our stock is all shaped up except for a little trimming around the action. The receiver being slightly cut away for the ejection of empty cases on the right side, the wood is sticking up a little along this edge. Take a rattail file and cut down at each end, against the barrel ring and receiver bridge, then cut out the excess wood between the file cuts with a sharp chisel, then file the wood thinner in toward edge of receiver, making it somewhat like Figure 65C, in Chapter 9.

If desired to use the magazine cutoff, the notch for it should now

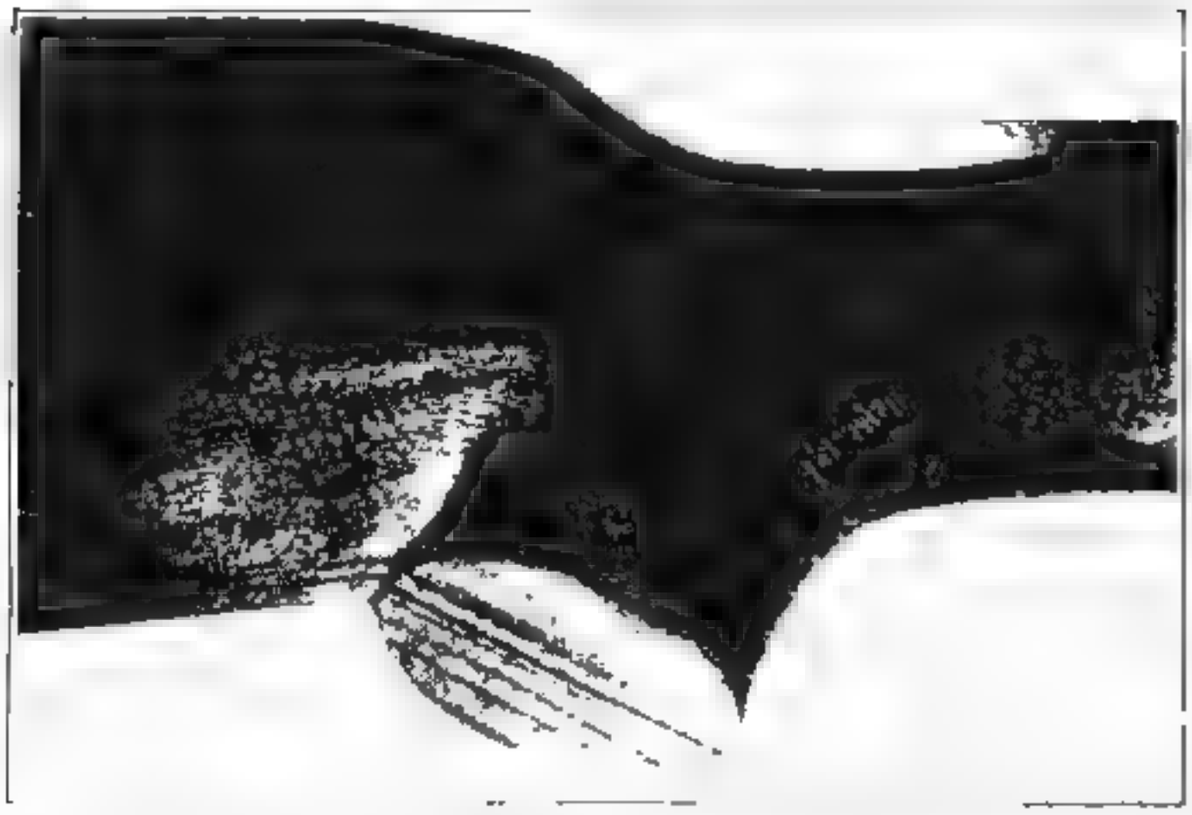

Fig. 90

be cut in left side of stock. Since a cutoff is not needed on a sporting rifle, I prefer to omit this notch on a Springfield stock, rounding off the stock at left of action just enough so the cutoff may be turned straight out for removal of the bolt. If the notch is desired, however, it need not be cut as wide or as deep as in the service stock. Make it just large enough to hold the cutoff, and let the latter turn down to an angle of only about 45 degrees, instead of nearly straight down.

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When the stock seems to be exactly right as to form and size, it is a good plan to assemble the gun and take it out for a little target practice. Try it out in all the positions you expect to use—you may find a few changes necessary. The high, snug fitting comb that seemed so perfect in the shop, may punish the cheekbone severely under recoil, necessitating cutting it down a sixteenth inch or so. Again, the comb may be too thick, or the cheek piece require tapering a bit more forward, or thinning at the bottom edge a trifle. No harm will be done by taking the wood file to the range and working down a little here and there as required. After all, there's nothing like the "cut-and-dry" method to really fit a stock.

Having assured yourself that the stock is right, the next step is sanding. Hold it in the vise, protected by the felt pads, and go all over it from one end to the other with a strip of No. 1/2 carborundum cloth, used like shining a shoe. Do not bear much pressure or you will make deep cross scratches. This preliminary cross sanding removes all the file marks, and takes out any slight inequalities in the surface.

STOCK IMPERFECTIONS. Now look carefully over the entire surface for imperfections such as "shakes," dry-rot, or small splits or knots. Often these do not extend to the outer surface of the wood, and show up only when the stock is about finished.

A "shake" is a small (or sometimes large) separation of the fibres of the wood, caused by the fatigue resulting from the swaying of the tree in the wind. It appears as a small crack or split, almost anywhere along the side of the stock. It may not be deeper than 1/16 inch, or it may run nearly through the wood. Unless located where it materially weakens the stock, such as at the tang, a shake will do no harm, and may be permanently repaired as follows:

Wet the stock where the shake appears, then dry over a good hot blaze This will open the crack slightly. Now, while the wood is quite warm, rub some thick orange shellac over and into the crack. Heat a bar of iron about as hot as for soldering, and rub it over the shellac, burning it into the crack. The iron should be hot enough to make the shellac smoke and smell. Sand off the surface, and if the crack is not fully sealed, repeat the treatment several times, or until it is sealed. Then sand down smooth, and when finished, this crack will never open. Very small splits and seasoning cracks may be treated in the same manner, unless located where they will weaken the stock.

Dry-rot often occurs in imported wood that has been in storage for years, with weather conditions not right—and sometimes it does not show up until the stock is all shaped and sanded. It is evidenced by a streak where the wood looks "powdery," the outer layer being partially separated for a short distance, and the powdered rotten wood beneath sifting out. Sometimes such a place can be worked out by reducing the dimensions slightly, but as a rule the deeper you cut

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the worse the condition. The best thing to do is treat the place with shellac as described for windshakes, after first soaking the spot with shellac thinned down with alcohol until scarcely thicker than water. Let this dry, then burn in the thick shellac several times, and sand off. If this doesn't cure the trouble, throw the stock away—and swear. The latter injunction is doubtless superfluous.

Very small "pin" knotholes can be plugged. Whittle out walnut splinters to fit, dip them in du Pont Cement, and drive them in, cut them off flush, and sand smooth.

Larger knotholes are sometimes plugged, and sometimes filled with Plastic Wood. The best way is a combination of the two methods. Find a scrap of walnut with a knot about the right size. Whittle and file this knot until it fits the hole easily. Coat inside of hole with du Pont Cement, then a layer of Plastic Wood. Coat the plug with the cement and drive it snugly into the hole, letting the plastic wood and surplus cement squeeze out around the edges. Let this dry at least 48 hours, file off smooth, and sandpaper.

After all defects have been repaired and the stock cross-sanded, it should be sanded lengthwise of the grain with Number 1/2 sandpaper or garnet paper, when it is ready for the final sanding and finishing as described in Chapter 13.

FITTING TWO PIECE STOCKS. When the principles and practice of inletting and shaping have been learned on any one stock, the worker will be able to go ahead on almost any other kind of stock with little difficulty.

These principles vary, however, with the two piece stock, on which some further instruction may prove helpful. On the bolt action stock the action is bedded straight down into the wood. With a two piece stock, the tangs must be let *down and back* into the grip portion, and a clamp like Figure 28C is the first essential. This may

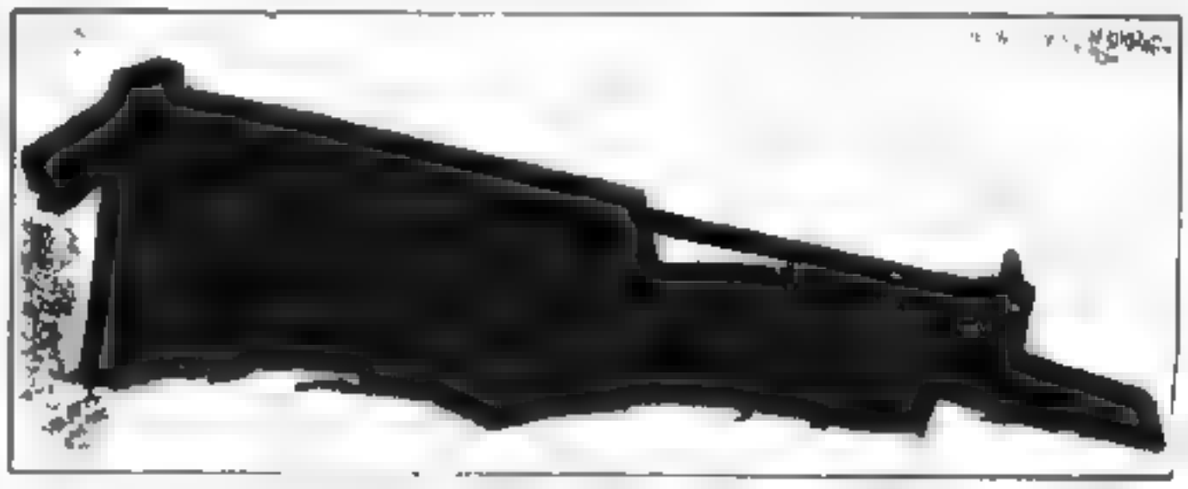

Fig. 91

be made of two 3/8 inch bolts about 15 to 18 inches long, and two pieces of cold rolled steel 1 inch by 3/8 inch, and 4 1/2 inches long.

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These pieces are drilled at each end to slip easily over the bolts. As the nuts are tightened up, the action is drawn back tightly into the stock

On many rifles the lower tang may be removed from the receiver, while on others both tangs are made in one piece with receiver. When possible, remove the lower tang; set the upper tang in position on upper part of grip portion of blank, and mark round it with a pencil. The tang of course will not go back to place, but will be somewhat forward of its proper position. Cut out the recess for the tang, working in the manner described for inletting the Springfield guard—cutting across the grain wherever possible. Coat underside of tang with lampblack and oil and try it in the channel you have cut. Remove the surplus wood as indicated by the black smudges, and carry the tang mortice back a little. When within 1/4 inch of its final position, put on the clamp as shown in Figure 91, and tighten it up—but not so much as to split the grip. Remove and continue the cutting, until finally the clamp draws the receiver firmly against the end of wood. If the angle here is not correct, it should be worked off as required with chisel or file, and the tang mortice carried back the required distance to make all joints tight. This fitting should be done with all working parts—springs, screws, hammers, etc., removed from the action and inside of tangs.

Now rasp down underside of the grip to nearly its final size, and

with the receiver and stock blank clamped together, fit the lower tang in place in receiver, and mark its outline on underside of grip. Cut the channel for it slightly undersize, then fit it tightly into receiver in its permanent position, and gradually let it back into the stock, just as you did the upper tang. When both tangs are fitted, locate and drill tang screw holes before the clamp is removed. Then remove the stock, replace hammer and trigger springs, and other inside parts. On old stock note the cuts for these parts, and rough cut them in the new stock. Coat all parts with lampblack, and let the assembled action into stock, cutting away any wood where needed, and drawing the receiver up tight with the clamp until the tang screw may be turned in to place.

The blank being fitted to the action, try the trigger, hammer, lever and other parts to be sure the wood is not binding at any point. If it binds, coat all parts with lampblack to show where wood must be removed, and trim out as required.

Now draw a center line back from the center of both tangs, and you are ready to fit the buttplate and proceed as already described.

The work is considerably more difficult when the lower tang cannot be removed from the receiver. Take careful measurements from the old stock; cut the grip portion of blank nearly to right thickness from tang to tang; cut both tang recesses slighily under size, and let them back gradually, as the clamp is tightened.

On most rifles the tangs are tapered toward the rear, which enables

the stocker to secure tight fit along the edges by carrying the inletting back toward the comb.

The Savage '99 Model rifle is easily stocked, although it looks like a tough job at first glance. Have your blank an inch or so longer than required, and mark on each end the center point for the hole to be bored through lengthwise, into which the long stock screw is inserted. This must be a two-diameter hole, as the head of this screw goes well up toward the grip. Measure the screw, and mark the position of the head on outside of stock, leaving about 1/2 inch extra length at receiver end. Now measure back from this mark to butt, and set a bit or drill of the right size to accommodate screw head in the chuck of a machine lathe.

This bit should project from the chuck the exact distance required to make the hole the right depth. Set spur of bit in center point on butt, and set the dead center in the tail-stock on the point marked on receiver end of blank. Turn the lathe slowly, holding the stock blank in the hand to prevent turning, and feed with the hand feed on tail-stock. When the bit is in the wood as far as the chuck permits, withdraw it, and insert another and longer bit in the chuck, this bit to be the size required for the stock screw. Replace the blank as before and continue the hole (the smaller bit will readily find the center left by the spur of the larger one) until point of drill touches the dead center in the head stock.

Now measure the width of tangs and lay out their outline on center line of stock. In case the drill happened to run a trifle sideways, locate your center lines with the center of the hole. With ripsaw and chisels; remove the excess wood and inlet the tangs to final position, using the stock screw to draw the blank up tight against receiver. The stock is now ready for final shaping up.

The above method of drilling a stock lengthwise may be employed on the Lee Enfield, the Ballard, or any other stock held by a screw set in through the butt. On the Lee Enfield, there is a deep socket at rear of receiver into which the grip is fitted, and the depth of this socket must be allowed for when cutting the blank to length.

In shaping up a stock thus attached, the exact position of the screw must be carefully penciled on both sides of the stock, so that you will not, perchance, cut into this screw in cutting the grip to shape. As a rule this hole comes close to the surface of the wood just ahead of the comb.

FITTING SHOTGUN STOCKS. Several of the pump shotguns have the stocks attached with a long screw through the butt, and the same method of boring the hole may be applied to them also. This scheme has a number of other practical uses—for example, the deep hole for recoil spring which runs back into the stock of most automatic shotguns. Boring this hole with brace and bit is an uncertain method. The position of the hole may be laid out on the sides of the blank, and its center line projected to a point in the

butt, which is held against the dead center in lathe, while the drill enters at the proper angle at front end of grip. It is evident that the mechanism of the arm would not function if this hole were not properly located and set at the correct angle—hence this lathe method eliminates all uncertainty.

It may be desired to restock some rifle having the magazine located in the butt, like the Remington or Winchester .22 Automatics—here again we have the only accurate and easy method of drilling the holes in the right place and at the correct angle.

The fitting of a stock to a pump or automatic shotgun is quite similar to fitting a two-piece rifle stock, and the same general instructions will apply. Once the tang is fitted to the blank, the stock may be shaped in any manner desired, following the working details already laid down for rifle stocks.

But stocking a double gun is a different matter—as previously stated, this is a job I dislike, and avoid whenever possible, because it is so everlastingly slow and tedious. Most gunsmiths, however, get a great deal more shotgun work than they do rifle work, and become quite adept at stocking double guns. The work is really very much the same as stocking a rifle with a two piece stock, and is only slower and more difficult by reason of the great amount of wood removed from the stock, due to the design of the action. Because of this, the thin walls of wood left are not strong, and the greatest care must be exercised to prevent breaking the edges.

The first move in inletting a stock for a double gun with side locks, is to completely strip the receiver of locks, trigger bar, top lever, locking lug, safety and everything that will come off. Get the angle of the recoil shoulder and saw your blank as nearly correct for it as possible. The blank should be extra full in all dimensions. Now inlet the upper tang and draw it in to a close fit with the clamp, just as you did in the two-piece rifle stock. Keep your tools very sharp and cut the edges clean—work slowly and take no more wood out than absolutely necessary. If using a full, square blank, let the tang in an eighth inch or so below the surface, to give you some leeway on final measurements. If using a rough turned stock almost worked down to size, you will have to take drop measurements as you go. This is done easiest with a long straightedge (I use a bar of hardened tool steel 4 1/2 feet long, 1/8 by 1/2 inch in size), resting the edge at one end on top of front sight, and on the matted rib at breech, the other end projecting back over the stock. From this edge the heel and comb measurements are easily made with inside calipers.

Next remove the triggers and springs from the trigger bar, fit the bar in place in receiver, and let it into under side grip. This is a job requiring care and patience. Keep the receiver tight against the stock all the while with the clamp. It is well at times to set a short wood screw into the upper tang also. The lug for tang screw

on trigger bar has a sloping shoulder. This shoulder, as well as the top of the lug, must fit tight against the wood—otherwise the tang screw will spring the trigger bar, throwing the whole works out of "kilter."

Next strip the lock plates completely, file the wood down nearly to proper width where they go in, and let in the plates. Their forward ends will start into the recess in receiver, and they may be gradually let into the wood at rear by coating the underside and edges with lampblack. Now, using the old stock to go by, sketch in with a pencil the outline of the inside recesses under lock plates, then locate and bore the hole for the scars. This should be bored through from both sides.

After rough cutting the recesses under the lock plates, assemble the locks, coat all parts with lampblack, and start them into place. Guided by the black smudges, cut out the wood as required, so the locks will go into place. Use care when inserting and removing the lock plates to prevent chipping the edges of wood. Best have a trifle of clearance all around—about enough so that a thin piece of paper can be inserted—and the oiling later will swell the wood enough to eliminate any gap. Bore the hole for the lock plate screw from each side, and set in the screw. Try the hammers to see if they cock easily—the tumblers may bind against the wood as the hammers are brought back. Now turn the stock bottom side up, fit the triggers into the trigger bar, and replace same in stock. Copy the recesses in old stock when fitting the triggers, and be sure they work freely. If they bind or catch, coat them with lampblack to locate the trouble When all is working smoothly, let in the guard. If the shape of

the grip on the old stock is to be changed, the rear end of guard should be first bent as desired, then let it in carefully to prevent changing its shape, and the grip will be right when the wood is worked down flush with guard. Now remove all parts from the stock, and again using the old stock as a guide, outline with pencil the additional recesses required under the tang, for top snap spring, safety, etc., and cut out the wood where necessary. Do the final fitting with lampblack, as before. In the face of stock cut out the hole for the locking lug, and other recesses as indicated by the old stock. Now reassemble, making sure that all parts work smoothly, and proceed to shape the stock as desired. (See comments on shotgun stock design in Chapter 9).

Box lock guns are fitted in pretty much the same manner, but the job is easier because there are no lock plates to be let in. Proceed as before, letting in the top tang first, then the trigger bar and other parts that go in from the bottom. So much wood is removed from the face of the stock that great care is necessary, also very sharp tools, to prevent splitting. At all times be sure to take out no more wood than is absolutely necessary—there's little enough left at best.

FORENDS. Since we started with rifle stocks, we will go back

to the point where our two piece butt stock was inletted and ready for shaping. Now comes the forend. On rifles, as a rule, the forend is easy to make and fit, being, in most cases, merely a grooved piece of wood held to the barrel by one or two screws, with its rear end sometimes set into a shallow socket in front of receiver.

First take off the old forend and study it carefully. Note any peculiarities it has, and decide how they may be most easily copied. Have your forend blank sawed out square, and an inch longer than desired. With the marking gauge scribe a center line all round. Mark with chalk the exact point on barrel where tip of forend is to be. Measure barrel at this point with outside calipers, and with dividers prick half this distance on each side of center line near one end. In the same manner lay out the diameter of barrel at other end, and connect the points thus formed with a fine line.

If the barrel has a straight taper, as most single shot rifles do, the work is going to be easy. If you have or can borrow a rabbetting plane, the groove may be cut out almost to size, and finished to taper with chisels, as already described. Gauge its depth and roundness with a try-square by the method given earlier in Chapter 10. Make the groove to fit the barrel easily at a point 1/2 inch *ahead* of its final position. Now coat underside of barrel with lampblack and oil, and fit the barrel closely, gradually working the forend back to final position. This method keeps the edges tight, without any possibility of gaps between barrel and wood.

If the end of receiver has a socket for the forend, as in the S. S. Winchester, coat this with lampblack and tap the forend against it —this gives you the outline for shaping the end. Cut the shoulder sharp and square as you work the forend back.

To locate the screw holes, first clean out the hole or holes in bottom of barrel, and sandpaper the barrel channel clean. Coat the barrel thickly with lampblack at this point and press into forend. Drill hole from the inside through the spot thus shown. To fit the escutcheon or bushing for the forend screw, use a sharp counterbore of the proper size to start it, or outline the hole with a small gouge of the right size, and chip out the wood inside the line. Then use a Forstner bit of the same diameter as the bushing, and press bushing to place.

Most of the shaping up of the forend can be done right on the barrel. It is nearly impossible to hold it in the vise safely and firmly. A good plan is to turn up a hardwood rod the same size and taper as the barrel, and a few inches longer than the forend, which is held to it with a wood screw through the bushing, then the end of this wood bar can be held in the vise and turned about as required.

Making a forend for tubular magazine rifle is not so difficult as would appear. Square up the blank, scribe the center line all round, and bore the hole for magazine tube in a lathe, as described for boring butt stocks. Lay out the shape of barrel channel on each end,

and cut out with chisels. Spot rear end and fit to receiver with lampblack; fit forend cap in the same manner. Then shape up as desired by rasping and filing.

When shaping the outside, be careful not to crack or split the forend, which is merely a shell of wood. A hardwood rod should be dressed down to a smooth sliding fit in the hole through forend, and this rod may be held in the vise while the shaping is done.

Forends for pump guns and trombone action rifles are bored out as already described, then fitted over a hardwood arbor and turned to shape and size. The upper edge is then planed or rasped flat to desired width, and barrel channel cut as before, after which the end caps are fitted by spotting with lampblack.

A forend for a Winchester, Remington, or Browning automatic shotgun calls for patience and careful workmanship. Due to the large hole for the magazine tube, its side walls are very thin and easily broken. Bore it out between lathe centers, using a very sharp auger bit, and turning the lathe slowly by hand, while holding the blank to prevent it from being turned by the bit. It may be necessary to use an expansive bit for this job, the shank of which will be too short to permit boring clear through the blank. In this case, bore half through, then turn up a hardwood cylinder to a snug fit in the hole. Reverse ends, centering the dead center of lathe in center of this wood cylinder, and bore until bit cuts into the cylinder. Now turn up another cylinder several inches longer than forend, on which to hold it in the vise—as this type of forend must be shaped with the rasp.

In my humble opinion, one of the meanest jobs in the whole field of gunsmithing, is the FITTING OF FOREND IRONS of double shotguns. The amateur who is short on patience will do well to buy his forend blank with iron fitted, from Schoverling, Daly and Gales, unless he is using the original forend iron on the gun. In that event he must fit it himself, as no two irons were made to quite the same shape or dimensions. The fitting, while seemingly simple, requires utmost care. Plane up your blank until it is just slightly thicker than the finished forend is to be. For the first time, attempt nothing more elaborate than the plain, shallow "regular" type of forend. Strip the old forend and keep it before you while you work. The job is similar to inletting the upper tang of the stock. As the tang is seated into the wood, the end of wood must at the same time be brought up tightly against the face of the iron at end. A wide opening vise in which the forend may be tightened up endwise, is a big help in this work. The tang must be bedded deep enough to take care of the shallow barrel grooves on upper surface. When the upper iron is fully fitted, drill holes for the screws, and fit the outside plate, cutting out wood where necessary to permit the catch to operate freely. It is difficult to hold this type of forend while shaping up, and it will pay to have the blank about three inches

longer than wanted, so that this end may be held in the vise while the piece is rasped and filed to shape. The barrel channels on upper side of forend should be smoothly sanded, and this surface polished and finished as carefully as the outside. A forend with inside unfinished indicates a sloppy workman.

Sometimes the owner of a double gun will want a big, "handful" forend on it. This is made in the same manner as just described, except that the deeper barrel channels must be cut before the forend iron is fitted. Spot the fitting with lampblack, and cut the channels almost to final depth. Then fit the forend iron, and deepen the channels until the catch operates freely.

CHAPTER 12

CHECKING AND CARVING

IT should not take long to say all there is to be said on the subject of checking, because the tools used are simple and few, and the actual operations are equally simple. About the only rule to be laid down is, first, learn the proper method of handling the tools to cut straight, parallel lines—then PRACTICE.

Some years ago Charles Askins, in answering an inquiry through Outdoor Life, remarked in an offhand manner, "Anybody can checker a stock." I am not disposed to contradict this statement since Captain Askins placed no time limit on the period that might be required to enable an operator to turn out a strictly first class job; nor did he limit the number of stocks one might be permitted to ruin in the learning.

Checkering, or to use the correct term, checking, is an art requiring the utmost concentration, patience, and perseverance to learn.

Moreover, it requires a lot of optimism; for just as sure as the inexperienced man picks up a checking tool and starts in on his first job—just so sure is he to ruin that job. Make up your mind to spoil a few—and in order that the spoilage may not mount into too much cost, start in on plain pieces of walnut.

CHECKING TOOLS. To start at the beginning, there are but two tools essential to the stock checker; these are the line spacer, and the V-tool, or deepening tool, as it may be called. These are illustrated in Figure 18 and the making of these and others is described in Chapter 4. The gunsmith will have a number of spacers cutting lines of varying distances apart; and he may also have a number of V-tools having different sized teeth, for hard and soft woods. The two tools, however, are all that are needed for the job, with a fine file for smoothing up the diamonds.

But more important than the cutting tools, is a suitable cradle

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for holding the stock being checked, so that it may be turned about as you work. Descriptions of the checking process usually omit all mention of this cradle, without which it is absolutely impossible to do any kind of a job. If I had to choose between doing without checking tools and doing without the cradle, I would choose the cradle, and try to do my checking with a saw file! Details of the checking cradle are illustrated and two different types are shown in the following photographs. One is made of a piece of hickory, 2 by 4 inches in size with iron brackets sliding in a groove on top, and

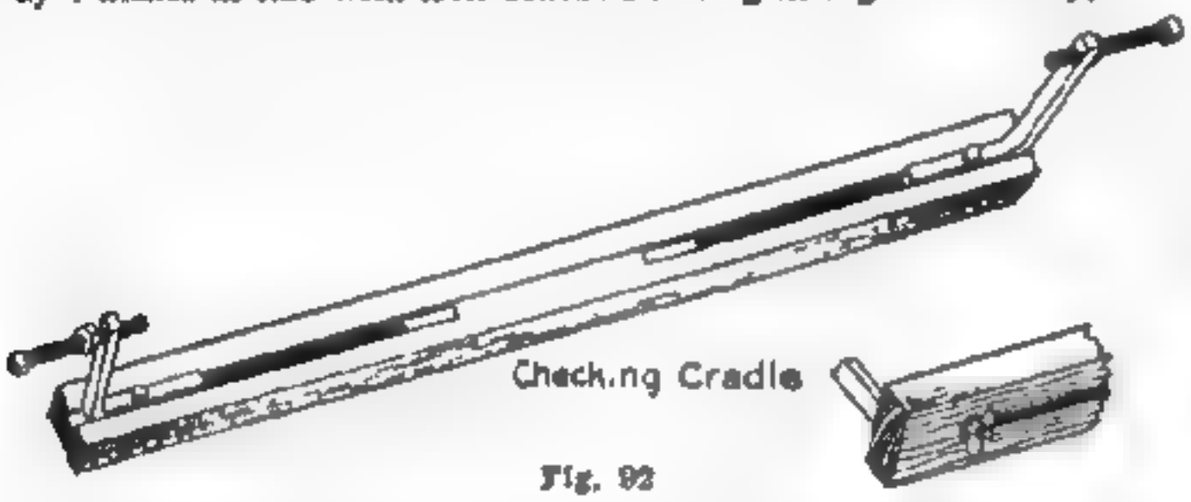

Fig. 92

held in position by a cap screw and wing nut. The other is made of 2 by 3 inch T-bar, and is unnecessarily heavy and clumsy.

The cradle is first set in a convenient position in the vise, and the stock set in the cradle as shown, using a round piece of wood laid in the barrel channel and held by a single wood screw, as a bearing point. The two set screws should be tightened up enough so the stock will not turn under pressure of the tool, but may be readily turned by hand.

PRACTICE CHECKING. Before starting on a brand new job of checking, it is best to have some practice re-tracing an old job. This requires the use of the V-tool only, and while this is usually the second tool used on a job, it is by far the most difficult to handle, so it should be mastered first.

The best practice I know of for the beginner is a double barrel shotgun forend, and since most forends have the checking pretty well worn down, it isn't difficult to find one. Moreover, the practice work I am going to describe will not damage the forend, even if this is your first attempt. So don't hesitate to try it on the forend from your own gun if unable to borrow one from a friend.

Cut a piece of 1 by 2 inch pipe long enough to fit between centers in the cradle. Set the screws up on each end of it, and fasten the forend, bottom up, to the middle of this piece, by a wrapping of tire tape about each end. Now take the V-tool and start in at one of the rear points in the checking design, holding the tool as shown in Figure 93. Note that right forefinger is extended alongside the

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shank of tool, not on top of it. The right hand exerts no pressure other than weight of the tool. Pressure is supplied with the left thumb, and should be *very light*.

Now push the tool forward in the line of checking, working it back and forth with a filing motion, but advancing it about one-half inch with each stroke. Let the tool follow the groove easily, and do not stand with the eyes directly above the work. Keep the hands slightly in front of you all the time—this makes it easier to see the groove and follow it in a straight line. Make no effort to deepen this groove to its full depth the first time over—barely clean out

Fig. 93

the bottom with the edge of tool. Work carefully to the extreme end of line—then STOP. No need for running the checking our over the border.

Now go back to the starting point and trace the second line in the same manner. Keep a stiff bristle brush handy and brush off the dust after tracing each line. Continue line after line until you have re-traced the entire design in one direction, then change your position, or swing the cradle around and retrace the cross lines in exactly the same manner.

The appearance of the checking will now be greatly improved despite the very light cut. Brush off the surface and start at the beginning again, deepening the lines *slighily*. Make every cut the full length of the line—dont think you can stop in the middle and then finish later from the other side. *It can't be done.*

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The shank of the tool should be in prolongation with the bones of the forearm and wrist. Never let the tool start the least bit to one side, and never tilt it, or it is sure to ride up the sides of the diamonds and jump over into the next line—spoiling a line of diamonds in the jumping. Keep the tool well out in front of you at all times, and "sight" along the lines frequently to make sure they are not wavering.

After going over the design four or five times you will find the diamonds almost sharp pointed, and if you have done your work carefully, they will be quite as even as the original checking when the gun was new. Now take your "checking file," which is an American Swiss three-square escapement file with the point bent slightly, as described in Chapter 4, and using it in the same manner as the V-tool, carefully go over the lines once or twice, bringing the diamonds up to sharp points.

If the wood is dry it is a good idea to keep a few drops of linseed oil on the brush which you use for brushing off the dust after each cut. This not only polishes the diamonds slightly, but also makes each new cut show up very distinctly, helping to prevent running off the line. When the job is completed to your satisfaction, retrace the outlines carefully with the V-tool, then with the file, then scour the diamonds vigorously with linseed oil on the brush; wipe off excess oil with a soft cloth, then brush dry with a clean brush, and the job is finished.

Having successfully re-traced the checking on a shotgun forend, don't get the mistaken idea that you are able to do checking. Repeat on three or four more forends, by which time you will begin to have some understanding of the possibilities and limitations of the V-tool. Then try a shotgun butt stock in the same manner. To hold the stock in the cradle, carve out a small block of sound wood to fit squarely against the recoil shoulders at front end of stock, with projections on the wood to reach into the action cuts. Tacking small blocks of leather to this piece will enable you to shape it easily

so it will not slip off the stock. Set one of the set-screws on cradle-bracket into this block, and the other one into the butt, after having removed the butt plate. If the stock has a recoil pad, hollow out a block of wood to fit over center of pad, and set the screw point into this.

Begin on one of the upper outlines of the grip checking, and follow it with the V-tool in the same manner as you followed the lines on the forend. Turn the stock as you advance the lines, so that the tool is always held in approximately the same position. Retrace all the lines one way, then go over the cross lines. Then take the other side of grip in the same manner. The lower curved portion of pistol grip is the most difficult point to check, as in following the unequal contour it is quite easy to let the lines run off a trifle to one side—which is ruinous to a good checking job. The shotgun

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stock is selected for beginners' practice because the grip has less curve, and is easier to handle than a rifle stock. The checking of a good close pistol grip on a rifle is a job for "few men and no boys" as the saying goes—and the closer the design approaches the forward lower curve of grip, the harder it is to handle. Moreover, a very full rounded grip offers far more difficulty at this point than one that is more nearly flat on the sides.

Having completed this retracing of the grip design with more or less success, try it on a half dozen other stocks. Then—and not sooner—you will have acquired a fair mastery of the V-tool, which will be a big help later. Some excellent further practice may be had if you can persuade your local hardware or sporting goods dealer to allow you to finish the checking on his cheaper guns. These usually are not checked at all, but are merely scored with shallow lines, and the appearance can be wonderfully improved by an hour or so of work with the V-tool. As a rule it is impossible to hurt the appearance of these stocks—and you might improve them some.

While doing this re-tracing of old checking for practice, you should prepare some scraps of walnut for practice with the line-spacer. Select pieces about the size of a shotgun forend, and round them off to about the same shape, sand them smooth, and give them a regular oil finish. They should be as well finished as any stock, and the oil should be pretty well cured in. In selecting scraps for this purpose, try to find some that are soft, some that are hard, some curly, some straight, some open grained and some dense. It is impossible to explain on paper just how some walnut handles under the tools—this must be learned by experience. Some walnut will permit the use of finer line spacing than others—this also must be learned by experience.

LAYING OUT CHECKING PATTERN: Now you are ready to start learning the first steps of checking. Select one of the pieces you have prepared, having a very hard, dense grain. Tape it onto the piece of pine as you did the first shotgun forend. Mark a pencil line down its center. About two inches from one end of this line, prick a dot with the divider point, or with an awl. Measure toward the nearest end 1 1/4 inches and make another dot. On each side of this dot, and at right angles to your center line, make another dot 1/2 inch from the second dot. Now lay a flexible straight edge, or strip of thin celluloid so that the edge connects one of the side dots with the first dot you made on center line, and mark a line with pencil connecting the two, and continuing until it runs off the side of the walnut. Next connect the other side dot with this same center dot, and continue the line until it runs off the other side. These two lines now form an angle which will make the diamonds two and one-fourth times as long as their width. Checkers' ideas vary as to what constitutes the correct proportions for diamonds, some even making the length four times the width. Usually the

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most pleasing ones will run from two and one-fourth to three times the width. If made more nearly square they will fall far short of being attractive.

Having the two guide lines laid on with pencil, take your line spacer which cuts parallel lines about 18 to the inch; don't try to use a finer spacer at first, even though practicing on a piece of hard close grained wood. Hold the tool as shown in Figure 94 and use it with a filing motion, the same as the V-tool, advancing the cut about an inch at each stroke. Keep the tool well out in front of

Fig. 94

you, and run it *straight*. Any bend or inaccuracy in the first cut will be copied and increased in subsequent cuts. The right forefinger should bear on the tool with very light pressure, the left hand adding slightly to the pressure on the point, but not guiding it. The right wrist and forearm does the guiding. Advance the cut carefully until you have two very light lines, one of them on the pencil guide line, the other close beside it. DON'T TRY TO CUT THESE LINES DEEP. The line-spacer is just what its name implies, and is not intended for deep cuts.

After cutting the first guide line, swing the stock cradle round and cut the second one in the same manner, otherwise the pencil line will be obliterated. Now go back to the first one, and continue cutting parallel lines. You may work to the right or left of the

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first line, as required—both edges of this tool are the same. Set the cutting edge close to the last line, with light pressure in the wood, move it sideways—"click"—the edge snaps into the line, ready to guide the next cut. Use a steady filing motion, always advancing a little with each stroke, and using constant care that the guiding edge *never* rides up the side of the cut.

At first you will find your lines spreading out fan-shaped, or running together. You will swear that the tool is no good, and the system worse. Only by practice can you acquire the steady, even stroke that pushes each line forward parallel with the preceding one. Another fault will be in permitting the lines to curve slightly toward right or left. They must be absolutely straight, regardless of the shape of the surface over which they are cut. Because there are almost no flat places on a stock, it is best to learn to work over rounded surfaces right from the start—then a flat surface will be mere child's play for you. Learn to cut the lines as straight as a die from one side to the other, no matter how rounded the surface, and you have mastered the essentials of checking.

Having successfully covered the surface with parallel lines running straight in one direction, next cut the cross lines, starting with the other guide line already cut. Cut every line its full length without lifting the tool. If they run out on you and you spoil the piece, file and sand the surface smooth, rub in some linseed oil and lay it aside while you try another piece.

First practice should always be with a fairly coarse spacer—cutting 16 to 18 lines per inch—and should always be on hard, dense wood. Soft open grained wood is very hard to check, and some of it will not check at all without "fuzzing" up the diamonds. The

walnut used in the D. C. M. Sporter stocks is among the worst in this particular, for which reason I always duck a checking job on one of these whenever I can. Later, after you have mastered the technique of the spacer, you can use narrower cutters, spacing the lines 20, 22, or 24 to the inch—this on hard close grained wood only Stick to the 16 to 18 line cutters for softer wood.

Having successfully spaced off the surface both ways—without any attempt at outlining a design—take the V-tool for a change and go over the lines to deepen them. This will be easy after your preliminary practice on old stocks. Don't try to finish the diamonds up to points—just go over them once or twice with the V-tool to keep your hand in. Then start in with the spacer again on another practice-piece. Use up the harder pieces first, then try your hand with the softer ones. Be sure to keep the brush handy and brush out each line vigorously—and always use a little oil on the brush. After you have successfully spaced off six or seven practice pieces, you may go back to the V-tool and bring up the diamonds to sharp points. Now—and not sooner—you are ready to try checking your first stock.

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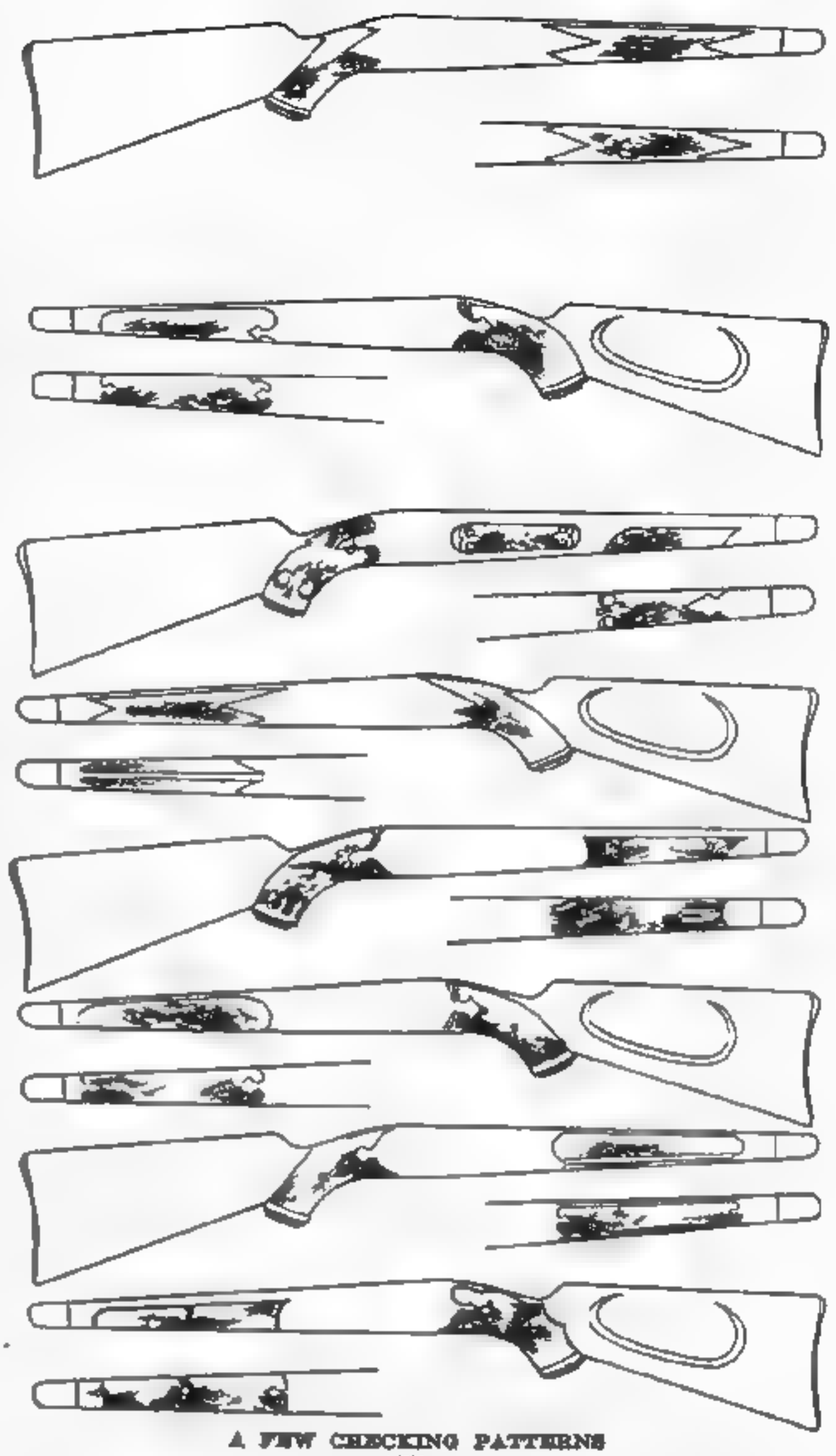
CHECKING DESIGNS: The first thing to do is to decide on the design. You may copy one from the plates shown herein, or you may copy the design from another gun, or you may make up a design of your own. The beginner, while admiring some of the curved or scroll outlines on high grade guns, is more likely to decide on a plain "point" design for his first attempt. And therein, more than likely, he makes his first mistake. The point designs, while appearing far more simple, are really much more difficult of execution than those having rounded or curved border lines. The reason for this is not hard to understand when you consider that the shape and size of the points depends entirely on the angles formed by the lines of checking. One may lay them out properly to begin with, then the least variation in spacing—and there is always some variation except with a few experts of long experience—will cause the checking to take a slightly different angle than was originally planned for it, so that the lines do not come up parallel to the border at the points, but meet this border line at a slight angle. Thus we have a "bastard" design instead of a true diamond-point—and you can find them on the best efforts of some of our leading makers.

When properly done the checking itself should form the border line of the points, and when it does not do so, you may know that someone has erred in his calculations. There are exceptions, of course, as when a design must be worked out to conform to some peculiar stock formation, when it is permissible to cut a border at an angle different from that of the checking lines. The very best English shotguns all have the points of the design formed by the checking lines themselves, and a perfect point design thus formed is the most expensive of all to produce.



A FEW CHECKING PATTERNS

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Nevertheless we have come to consider the various curved border designs as the most ornate and representing the highest quality; so there is no objection to the beginner selecting such a design, as he will do much better with it, and be prouder of his results, than if he attempted a diamond-point and failed to do it correctly. And if successful it is not necessary that he explain all this.

The photos and line drawings shown herewith should prove helpful in choosing a design, or at least in giving the aspiring checker a starting point from which to work out an original design for himself. Full size outline patterns should be useless, as the varying shapes and sizes of grips and forends do not lend themselves to any standard size or shape. Some of the end curves, fleur-de-lis, and other shapes, may be transferred, however, and the result of the design worked out from them. To transfer a design, first trace it from the page on fairly heavy tracing paper; then with a sign painter's "pounce wheel" (similar to a dressmaker's "tracing wheel" but much smaller) the outline on the paper is perforated. This is then called the "pounce pattern." To use, lay it on the wood in correct position, and rub it over with a small wad of cotton dipped

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in lampblack, to which a very little turpentine has been added, transferring the dotted outline onto the wood.

Before laying out any pattern on the forend, first draw a center line in pencil, and take all measurements from this line. Then lay on the end pattern if one is used, and transfer the outline. Sketch in the balance of outline carefully, measuring at all points from the center line with dividers to get it alike on both sides. The checking should extend up the sides of forend to within 1/4 or 3/8 inch of the edges. It is entirely permissible to work up a design wherein the checking is in two sections, separated up the middle by a straight or wavy "ribbon" of unchecked wood. The grip may also have such a ribbon separation through the middle of the design on each side, and if artistically worked out they are very attractive. Many a man has raved over the design of checking used on his gun, little thinking that the ribbon was worked in to separate the otherwise long lines, thus making the job much easier, and helping to prevent mistakes. It's a wise gunsmith who recognizes the limit of his ability!

I would strongly recommend that the beginner's first forend job should have the checking thus separated up the center. Cutting a perfect line from one side clear across to the other tasks one's abilities to the utmost; and while you may have had plenty of this sort of practice on the scrap pieces, remember this is a stock you're about

to work on, and you can't afford to spoil it. Keeping perfectly straight even spacing from one side of a deep rounded forend to the other is not a job to be undertaken facetiously, nor without much prayer and meditation.

Having the design marked out carefully on the forend, which we will tackle first, take the checking file with point slightly bent, and go over this outline very carefully, cutting it very lightly into the wood. Now decide on the shape diamonds you want. If you decide on "3 to 1," let us say, proceed as follows: Measure off 1 1/2 inches from the end of design and make a mark on center line. Now make a mark on each side of center line at end, and one-half inch away from it. Connect these points with two lines which will cross each other at the correct angle to give diamonds 3 times as long as their [illegible]

Now decide on the width of your spacing, making use of the experience gained on the scrap pieces. Better not undertake to make too small diamonds on this first job. The practice work may have led you to have confidence in yourself, but it is best to take no chances. Good 18 point checking is preferable to poor 24 point diamonds.

CHECKING THE FOREND: Select the line spacer you propose using, and start off exactly as you did on the scraps, first cutting the two guide lines you have ruled off, then going back to the first one and filling the entire outline with parallel lines run-

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ning in one direction. Again—*do not try to cut these lines deeply.* Just a faint scratch the first time over; then, the other side of spacer running in this scratch as a guide will deepen it, while scratching another line; again, the second line will be deepened while the third one is scratched, so that when the space is filled each line has received two light cuts—and this is enough. Brush off the dust after each line is cut, and always use a little linseed oil on the brush. When all the lines are cut one way, start in at the second guide line, and cut them all the other way. Should you find the spacer riding out and "wide spacing" or "narrow spacing" at any time, stop immediately. With a fine file carefully work off the lines at this point; rub smooth with fine sandpaper, and go over and correct the spacing. Nothing so mars a job of checking as extra or "dutchman" rows running part way across the design, and tapering off into nothingness. They are absolutely inexcusable, and no self-respecting stocker would turn out a job with them, even if he had to make a new stock. Here is another reason for making the spacing lines very light—mistakes may be corrected without materially affecting the shape of stock.

Start the lines as close to the border line as possible without actually touching it with heel of tool. The finish ends can be brought up close to the opposite border line—actually touching it, if one is careful, without running over it. Then go back from the other side and finish the first end up against its border line.

The lines having been evenly spaced in both directions, they are then deepened with the V-tool, working carefully up against the border line, or rather the outline at each end of cut. Use the V-tool with light pressure, just as you did in re-tracing the old checking design. Do not try to finish the lines to full depth in one direction first—you will simply obliterate the cross lines, and it is impossible to space them correctly after the first lines are cut deeply.

Keep going over the lines, first one set, then the other, gradually deepening both sets until the diamonds are nearly sharp. Then finish with the bent file as already described.

Getting into very small corners, short curves and angles is difficult with the spacer as well as with the V-tool. Do not try to work too far into such spaces, or you will run over the outlines and spoil the job. Work in as close as you can conveniently by tipping the tool slightly toward its point, then make the rest of lines with the file, as there will be only four or five such lines, and they will be very short. It is often best to omit this corner work until the diamonds have been entirely completed. Then take care of them with the file when touching up.

Having checked the entire design, go round the entire outline with the spacer, the inside of tool riding in the light outline first made, and the outer teeth cutting a second line. Use the cutter thus on all straight sections, and if you handle it well you can use it on the

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wider curves. Do not try to run it around very short curves, however, but use the point of the bent file, and space it carefully by eye. Now deepen both these outlines with the V-tool along straight sections and wide curves. On narrow curves, use the small veining chisel mentioned in Chapter 3. This double border line should be about the same depth as the diamonds, and spaced the same. Fancy triple border lines are out of place on curved designs, as the three-cut border tool will not follow the curves. A single outline is in still better taste, but should not be attempted until you have had considerable experience. The double line is recommended as being neat, and is a help in hiding any small marks where the tool has run over the first outline.

Inspect the checking carefully, touching up the lines at ends with the file, and deepening slightly where necessary. Finally, give the checking a good scouring with stiff brush and plenty of linseed oil. Then wipe off all the oil, brush with a clean brush, polish up around the edges with the hands—and there you are.

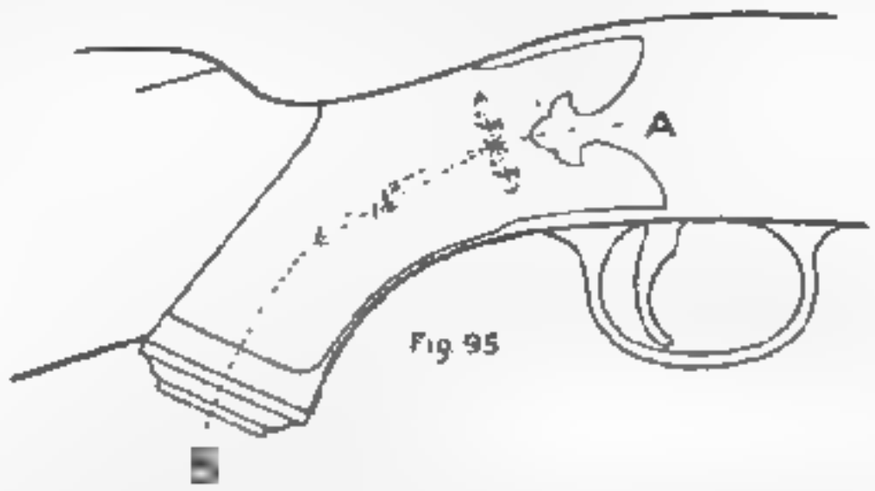

Fig 95

CHECKING THE GRIP. Now for the grip. Select a design to harmonize with the forend design, and if possible make pounce pattern for the end shape. The same pattern can be used on both sides of grip by turning the pattern over. First, draw a center line A—B, Figure 95, following the curve of the grip. Lay out the proper distance to form the desired shaped diamonds on this line, just as you did on center line of forend. Cut the two guide lines in the same manner after marking the outline of design and cutting it lightly. Then fill in the spacing lines as before, working on both sides of guide lines until the space is filled, then deepen these lines with the V-tool and finish as before.

In laying out a grip design, the checking should not run too far under bottom of grip, for here you get into difficulties. You are cutting on an inside curve here—a mighty difficult thing to do,—and the less you have of it, the better you will get along. Draw a center line on bottom of grip, from rear of guard to grip cap, and for your first job, better let the checking stop 3/8 inch from this

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center line, leaving a 3/4 inch strip unchecked. When the second outline is cut this will be reduced in width to nearly 1/2 inch, which is as close as the checking runs on most high grade arms. One may have a terrible yearning for checking all over bottom of grip—but try and do it! There is no objection to cross scoring the grip at this point, but it really is not necessary. Good sharp and attractive checking on sides is enough for most of us after one attempt on the bottom.

Some of the best and most expensive stocks now have the checking extend across the top of grip back of the tang. This is an excellent idea for the shooter who places his thumb across the grip, but is not necessary for those who shoot with thumb along the side. If the grip is to be checked clear across, plan your design with this in mind. There are very few cases where one can so plan to cut angles on each side so that the lines can be continued clear across. If you start from one side and run on over to the other, the diamonds on that side are almost sure to point in a different direction. Quite likely they will run at right angles to the grip instead of the long way. The safe plan is to score a very light line from center of tang, back toward center of comb, and work the checking from each side stopping at this line. Or, the design of each side may stop short of the upper surface, on which a small separate design is used. This method eliminates the break in the line of diamonds at center of grip.

POINT DESIGNS. If you do not favor the curved outline patterns, and decide to tackle a diamond-point design, first lay out your center line as described, then locate the desired position for the first two points on one end; space them at such a distance from each side of the center line that when connected with it they will give you the desired shaped diamonds. Now starting at these points, cut the first

two guide lines as before. With a narrow strip of transparent celluloid, lay off the other points and mark them lightly with lead pencil. *DO NOT CUT THE OUTLINE OF DESIGN YET.* The first two guide lines form the outlines of the first two points. Proceed with the spacing as before, but do not work quite up to the pencil outlines until you see where you are going to come out. Any variations in spacing will throw the points formed later into different positions and angles than those you started with. A well designed pattern on a high grade stock is a big help at this point, for you can study it and see how the checker has worked out his design. As you continue the spacing you will see where other points can be developed at ends of design, and these should always be in prolongation of the like spacings themselves. Sometimes, but not always, the first two guide lines which form the first two points can be made to form the second pair of points at the opposite end. This will depend largely on the shape and proportion of the diamonds formed. If you cannot get the shape you want on the points by extending the checking lines, then do not hesitate to make a bastard design by cutting the points

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as you want them, and letting the checking meet them at a slight angle—remember better checkers than you and I have done this often.

After spacing lines are cut, deepen them with the V-tool and finish as before, then cut a double outline all round, or if desired use the three-line border tool. You will have no difficulty with this tool on straight outlines.

CARVING. I seldom attempt much or any carving on a gun stock; first, because I am not a wood carver, and claim to know very little about the work; second, because in my opinion, elaborate carving is out of place on any gun. Study the work of the best English makers, and you will find simple, but beautifully executed checking even on guns having hundreds of dollars worth of engraving on metal parts. Good fine checking is an art in itself, and so is wood carving. There is no objection whatever to finishing the end of a checked area with a simple oak leaf pattern, or perhaps a conventionalized floral suggestion; provided you can develop the skill to do it well. Otherwise, better let it alone, for poor carving is the cheapest, and shoddiest looking thing on the face of the earth.

If you must have a carved stock, I would recommend that you study first one or more of the several elementary textbooks on carving, and practice on plenty of scraps, until able to turn out something you are not ashamed of. The hollow carving chisels made by J. B. Addis & Sons are best for this work, and you will use sizes of 1/4 inch and smaller almost entirely. The chisels must be honed and stropped until they will cut the softest white pine or basswood *across* the grain without the least bit of tearing. Then practice making curved cuts with the gouges, straight cuts starting narrow and shallow and ending wide and deep; practice with the 1/16 and 1/32 inch round and V-veiners, until you can cut in any direction without tearing or splitting. Then practice sketching designs—always of the simplest sort—until you can turn out something artistic, yet not complicated or hard to cut.

When planning a carved border on lower part of grip, for example, the grip where the carving is to be should be left about 1/16 inch thicker on both sides. Then draw your design on transfer paper, make a pounce pattern of it, and transfer the pattern to the stock. First cut the outline with a 1/16 inch V-veiner, then deepen it as required by straight cuts with straight or hollow chisels, according to shape. Then with a nearly flat hollow chisel, cut away the background portion, bringing the rest of grip to desired thickness and contour, leaving the portion to be carved stand out in low relief. Carve up the leaves, scrolls, or whatever the design contains, using the veiners for forming the outlines, veins and other shading lines. Don't cut too many lines—simplicity is the keynote of good carving.

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Round the edges and shape as the design calls for. The cuts should be so smooth that no sandpapering is required, as this ruins good carving. The places where the background was cut away, however, must be filed and sanded smooth, and well oiled before checking. Work the checking up close to the carving, and where impossible to use the tools in small corners, finish off with stippling, using a No. 6 wood carver's marker. These can be purchased from Hammacher & Schlemmer & Co., New York City. Or, a small prick punch, with point slightly blunted, may be used, but the work will be slower by reason of the single point. When finished the carving should be well oiled and carefully rubbed to a polish with the fingers, taking care not to get too much oil in the checking, which will fill up and gum between the diamonds.

When working up a leaf design at the end of a checked area, the points of the leaves should always run in toward the checking, originating in the solid wood outside the design. When the leaves point out away from the checking they give one the impression that they are ready to blow off and leave the stock bare. The stem ends should be worked out to blend and disappear in the wood outside the design.

There is another method of stock ornamentation that I have never seen described, which was quite popular for other uses some fifteen or twenty years ago. This is called Pyrography, or wood burning, and many readers will recall it as a popular fad among young ladies for making glove boxes, wall plaques, and other useless articles, which were usually constructed of thin white wood, on which the aspiring artist burned pictures of flowers, fruits, Gibson girls, Dutch mills, and the like. It seems a pity that some really practical use for Pyrography was not discovered before the manufacturers stopped making the equipment.

Pyrography outfits are hard to find today. I bought one three or four years ago from a company located in St. Louis, Missouri, the cost as I recall it being about eight dollars. Without a doubt a little attic exploring will bring many an old outfit to light.

The outfit consists of a platinum point or needle which is hollow, and is attached to a cork insulated handle so that it may be used as a pen in tracing the designs. The handle is connected by rubber tubing to a bottle of benzine, which is supplied with air pressure by a small hand bellows or rubber bulb. To use, the point is first heated in an alcohol torch until white hot, then pressure on the bellows feeds the benzine vapor to the point, maintaining an incandescent heat. The point is then used to trace and burn in the desired lines, dots, or other shapes.

Figure 96 shows a Pyrographic outfit complete, also a walnut panel with a number of background designs that should prove both attractive and practical on a stock. The work is quite easy, and a very little practice will quickly give the operator the knack, enabling him

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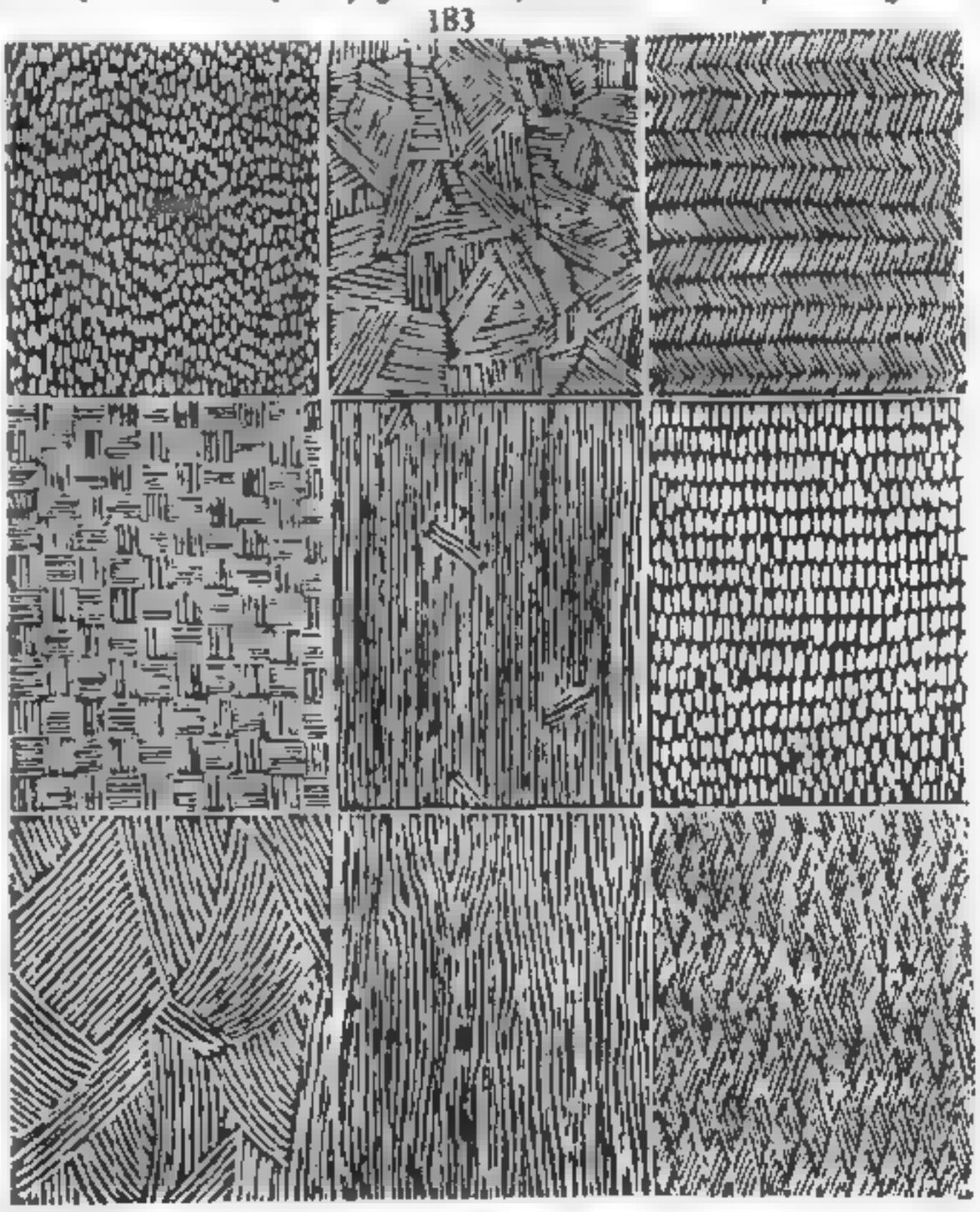

Above are a few background designs which may be adapted for use

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to turn out a creditable job. Thus a magazine picture of a game head, floral or other design can easily be cut out and made into a pounce pattern, transferred onto the stock, and the design burned in. Very fine shading of detail is possible, as almost hair-lines can be made with the platinum point. The same point will make large deep round or oval dots which give a splendid grip.

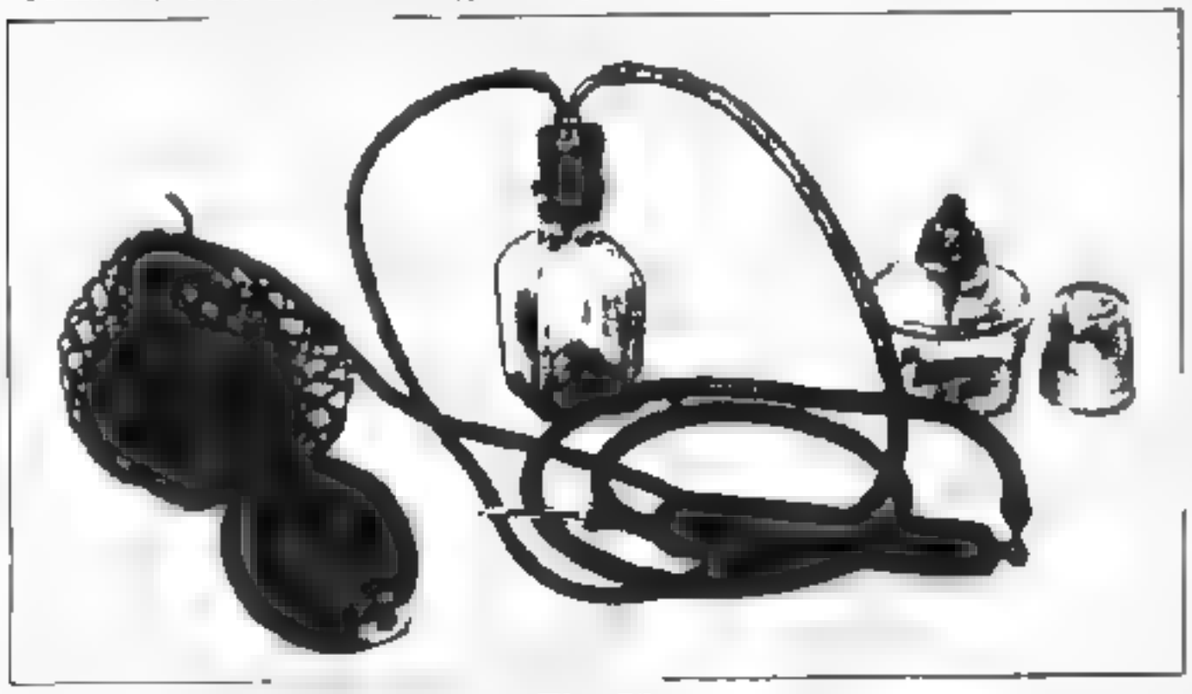

Fig. 96

For pyrographic decoration the work must be perfectly dry, clean and free of oil, paint, varnish or filler. Any of these will ruin the thin delicate point, and usually break it. Do the work before any finishing or polishing has been done. When the background work is finished, take a stiff bristle brush, or better, a brass wire brush, and brush out all the charred wood, making it as clean and free of dust as possible. Then oil over design and all, but scrub excess oil out of the burned areas before it dries.

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Chapter 13

FINISHING AND POLISHING STOCKS

IF ALL the magazine articles on this subject were assembled into a single volume it would probably contain more pages than this book—and variety would *not* be its outstanding characteristic. Every time the gun writers run out of material they sit down to the typewriter and hammer out a set of stock finishing instructions, which seldom vary in any essential detail from dozens of previous blurbs. The substance of all of them seems to be that the "London" oil finish can be produced only by bone-breaking, muscle rending labor extending through many months, with pure, unadulterated "kettle-boiled" linseed oil as the sole medium. And whenever the finish produced does not come up to expectations, the finisher invariably blames the oil.

There's plenty of absolutely pure raw linseed oil on the market—and by linseed, I refer to the natural oil pressed from flax seeds, and not adulterated with cotton-seed oil, or fish oil. As for "kettle-boiled" oil, that's a horse of another color.

The Archer-Daniels-Midland Company of Minneapolis, makes the following statement: "As for boiled oil, we do not believe there is anyone selling the kind of boiled oil you describe made in a kettle over a fire, as such a product would be of so dark a color that paint manufacturers and painters would not use it. Our boiled oil, however, is heat treated and the proper amount of suitable drying compounds incorporated into the oil to give the desired drying time. Boiled oil cooked in a kettle over a fire will dry a little faster than raw oil, but will not satisfy the paint trade which requires an oil drying in from 12 to 18 hours; whereas raw oil dries in from 72 to 80 hours."

I was so impressed with the frankness of the above concern in stating they did not have what I wanted, instead of trying to sell me what they had and evade the question, that I tested their raw oil

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thoroughly, and decided that it was the best available for gunstock work. They guarantee it to be absolutely pure, and its performance indicates that this is true. A-D-M oil is used and sold by many paint manufacturers, jobbers, and dealers, and can be obtained without difficulty if you insist on it.

I also decided, in view of their explanation, to quit worrying about "kettle-boiled" oil and use their regular prepared boiled oil for better or worse. And it has proven "all to the good." Litharge is the principal dryer used in this oil, which cannot be considered objectionable in view of the following, quoted from U. S. Army specifications No. 3—142, dated March 24, 1927: "V. DETAIL REQUIREMENTS. Boiled linseed oil shall be pure linseed oil that has been treated (preferably by heating—kettle-boiled) with compounds of lead, and at the option of the manufacturer with suitable compounds of other drying metals, so as to produce a product that will dry rapidly. It shall be clear, free from sediment, and shall meet the following requirements:—" (This is followed by technical specifications of no interest or value to the stock finisher.)

A comparison of the above with the manufacturer's statement previously quoted, indicates that this company is producing an oil which is in keeping with government requirements, and further, that the government finds this processed boiled oil suitable in all respects.

Be that as it may, the subject of boiled oil doesn't worry me very much for I use mighty little of it. Pure raw linseed oil will do (for me, at least) anything that boiled oil will do—and it will do it better. It is more penetrating, going deeper into the wood, hence a better preservative. Let it be known, however, that despite popular belief, linseed oil is not a waterproof finish; and the higher the polish given an oil finish, the more susceptible it is to spots from raindrops or water splashed on it. Its chief value lies in the fact that it will not chip or crack off like varnish, leaving the wood totally unprotected; and when the stock is thoroughly impregnated, the absorption of moisture in damp climates will be reduced to a minimum.

Now let it be known that I do not confine myself to the use of linseed oil exclusively in the finishing of stocks. Call it heresy or what you will, I use, as occasion demands, raw oil, boiled oil, varnish, shellac, and cup grease—and in a pinch I can produce a good "oil finish" with floor varnish and axle grease! Now that the bullets of the horror stricken cranks have all flattened and ricochetted from my tough hide let's go on.

Varnish is nothing on earth but boiled linseed oil, plus a little turpentine, and perhaps other dryers, and a liberal quantity of copal, spar, or other hardening gums. It is applied to the surface of wood, and does not penetrate to amount to anything. It preserves only while the coating is intact—not broken or scratched. Oil alone, on the other hand, sinks below the surface of the wood, and the protective coating it forms is a part of the wood itself. Oil finishing

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changes the character of the surface of a piece of wood, without actually forming an additional coating. Therefore, if a means is found for using varnish so that it functions *within* the fibres of the wood instead of forming an outer coating, such a method will prove valuable in many cases as will be explained later.

For there is no set rule whereby all stocks may be finished, any more than there is a set rule for treating all diseases. Some will respond better to one treatment, and some another. It is up to the stock finisher to study his wood, and employ the finish that will produce best results in the least time.

Very hard, dense, close-grained wood needs a finish that penetrates well; soft, open-grained wood requires a method of stopping penetration when the oil has gone deep enough. Maple, Apple, Hickory, and Cherry belong in the first class, along with the better grades of Walnut; while the softer Walnut, Koa, Mahogany, Oak, and perhaps others, belong in the second class. The white or very light colored woods such as Maple and Apple must be stained to give them the much desired dark color. Walnut, Mahogany, and the darker woods will darken sufficiently (entirely too much, in some cases) from the oil alone. Sometimes Walnut becomes too brownish, and sometimes too reddish. All these things must be taken into consideration by the finisher, and corrective measures applied.

Sometimes, moreover, the finish that will produce the desired color tone will have the effect of hiding much of the beauty of the grain. Any finish that does not increase and develop the natural beauty of fine wood is inefficient. Quite often a piece of Walnut that appears mediocre in the blank, may, by proper finishing, develop un-dreamed of beauty of grain.

The essential steps in producing an oil finish on a stock, are (1) preparation of the wood; (2) staining (if necessary); (3) penetrative oiling for color tone and to preserve the wood; (4) stopping

penetration when it has proceeded far enough; and (5) oiling for polish and development of natural beauty.

PREPARING THE STOCK FOR OILING. Let us assume we are working on a new stock, which has been shaped up and sanded (with No. 1 sandpaper) sufficiently to remove all file marks. The purpose of the present operation is to make it as smooth as it can be made, and at the same time open the pores to receive the oil.

The No. 1 sandpaper with which it has been smoothed up has left its own marks, and the pressure of the rubbing has mashed into the pores the fine slivers or "whiskers" which will block the oil and delay penetration if not removed. The beginner will be inclined to start in and dry-sandpaper the stock as smooth as possible now. But a moment's thought will show that the stock may be "whiskered" at the same time it is smoothed up, thereby saving much time.

With a sponge or wet rag go over the surface and wet it thoroughly, then dry off lightly with another rag. Immediately, hold the

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stock close to a gas burner or other source of quick heat, moving and turning it about, drying it within a minute or so. Keep the stock close to the heat so that the water is turned into steam rapidly, and in escaping it pushes out the whiskers further than if dried more slowly. Keep it moving slowly to avoid scorching—and be particularly careful of the thin edges at barrel channel and action mortices.

As soon as dry, go over it carefully and *lightly* with No. 0 sandpaper, or preferably garnet paper. Heavy rubbing will mash the whiskers back into the pores instead of cutting them off.

Now examine the surface under a good light; if the coarser sandpaper has left scratches that show, go over them with the No. 0 until they are eliminated and the surface very smooth at all points. Don't use a sandpaper block, but fold a quarter sheet for convenience in handling, and hold in thumb and fingertips. *DO ALL SANDING IN LINE WITH THE GRAIN FROM THIS POINT ON,* except around the curve of the grip, which curve may be followed, as the sides of grip will be covered with checking and slight scratches here will not matter.

Having removed all coarse sandpaper marks, repeat the wetting and drying and sanding with No. 0, until the whiskers will no longer raise when stock is wetted and dried. Use plenty of sandpaper—discarding it when it shows wear, so as to keep cutting the whiskers off instead of mashing them in. When no more will raise, take some well-worn sandpaper and polish the wood as slick and smooth as possible. Good hard wood will take a sort of polish under this treatment, and this "dry shine" greatly improves the final finish. Now, having the stock as smooth as you can make it, and all whiskers removed, wet and dry it once more to expel the dust from the pores and open them up. This completes the preparation of a new stock for oiling.

OLD STOCKS to be refinished must be cleaned off down to the bare wood. Don't attempt to remove varnish with sandpaper as you'll never get it all off, and the final finish will be streaked. Make a boiling hot lye solution—about a heaping tablespoon of lye to a half gallon of water, and holding the stock above it, splash and scour with a scrubbing brush until the varnish is dissolved and washed off. Rinse in clean warm water and dry, then proceed same as with a new stock. This treatment removes all the old filler and leaves the wood bare. It will appear quite dark while wet with the lye solution, but after rinsing and drying will have its natural color.

This same treatment should be applied to old service stocks, which have been partially remodeled, or to D. C. M. Sporter stocks after trimming down, to remove as much of the old oil as possible—otherwise, subsequent oiling operations will result in a spotted finish.

STAINING: To darken maple or other light colored and very close grained wood the commercial stains known as "acid" stains are best. Both Johnson's Wood Dye and Ad-El-Ite stains are excellent

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for this purpose. Use "Walnut" or "Mahogany" or "Weathered Mission Oak" or any other color desired. Generally I find that a mixture of two parts of "Walnut" and one part "Light Mahogany" gives the best color for stocks. Apply the stain with a brush or sponge to the bare wood; let dry half an hour, then rub with clean dry cloth. If the color is not dark enough a second coat may be applied.

Beware of stains on walnut! Unless the color is very light indeed, the oiling may be regulated to give the desired color tone. If stain must be used, first apply a coat of linseed oil, let soak in for an hour, wipe off and dry three or four days. Then apply the stain and the grain will not be hidden as it is with stain applied directly to dry walnut.

Old time gunsmiths sometimes darkened maple stocks by applications of aquafortis or ammonia; sometimes they wrapped the stock with a piece of tarred string wound spirally, then burned off the string, which scorched in a sort of "fiddleback" effect. Some of their stocks were varnished, and some were hand rubbed with soot and oil, which further darkened the color.

Sometimes a backwoods gunsmith would "figure" a stock by laying on a train of gunpowder and burning it off. I once tried this on a light colored walnut stock, with fair results, but the color, as produced with black powder, was very shallow, and much of it disappeared under the oiling. I tried another piece using a slow burning smokeless powder with better results. But while such methods of artificial graining may fool some, they never fool the owner of the gun—so why bother? Select the right kind of wood for your stock and you won't need to singe curlycues on it!

The use of any pigments or solid coloring matter should be avoided so far as possible, particularly on walnut. This is the reason stains are not very successful—they color the light spots and the medullary rays all the same shade, and hide the grain. The real beauty of walnut is in its contrasting colors, and these are brought out to best advantage with transparent oils containing no solid pigments.

PENETRATIVE OR FIRST OILING. The purpose of this operation is to drive into the wood, as deeply as possible, an oil which will afterward oxidize slowly and bind the outer fibers of the wood firmly together, while partially sealing the pores. For this purpose there is nothing better—nor half as good—as pure, raw linseed oil. Warm the stock slowly before a fire for a half hour, until it is quite hot, and also warm the oil until it is just a bit uncomfortable to handle. If the wood is very close-grained, thin the oil with 1 part pure turpentine to 3 parts oil—otherwise omit the turpentine. Apply the oil liberally with a rag swab on a stick, both inside and outside, and on the butt end. Rub with the swab while applying, and keep the stock warm while applying. Stand it on end in a pan and let it drain, turning it end for end and applying more

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oil every few minutes for an hour or so. Now let the stock alone! Don't apply any more oil, and don't do another thing to it but turn it occasionally for at least a week; and if you're not in too great a hurry, two or three weeks will be better still.

Time is the best stock finisher in the world; and if you keep on applying oil before this first coat is completely oxidized by the air, you'll have to do about double the amount of work actually necessary. Too much oil, or too rapid application, is worse than none at all. The thorough and complete drying of this first coating is the secret of a perfect finish.

A somewhat better method, but practical only in shops doing considerable stock work, is to use a sheet iron tank like Figure 97, slightly larger over all than the stock, and five or six inches deep.

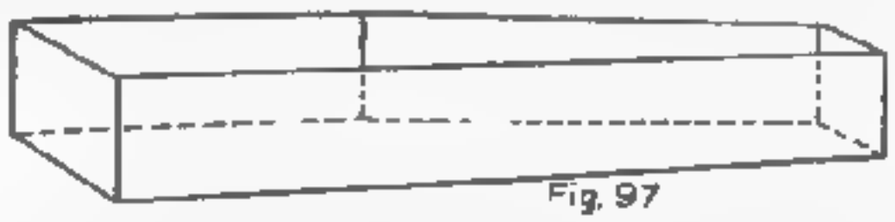

Fig. 97

A gallon or so of oil will be sufficient, as the stock will displace a lot of it, and you only need enough oil to cover the stock. The tank may be tapered toward one end as shown to reduce its capacity, and seams should be welded, not soldered.

Warm the stock thoroughly, and heat the tank of oil over stove or gas burners, but do not let it boil. When the stock is well heated through, put it in the hot oil, turn off the burners, and leave the stock until the oil has cooled to the temperature of the shop. Remove stock and stand up to drain, leaving it as long as possible—four days at least. Complete drying will take place quicker when the oil is applied in this manner.

STOPPING PENETRATION OF OIL. The first application should have penetrated from 1/16 inch to 3/16 inch below the surface of the stock. If wood is very soft and spongy this penetration may go on indefinitely, resulting in an oil soaked stock which

will never take a good finish, and which will ooze oil under the checking tools, making clean sharp diamonds impossible. The next step, therefore, is to stop further penetration, so that subsequent oilings will build up in the outer pores, producing a finish.

There are several ways of doing this. If the wood is very soft, with large open pores, apply a coat of the following mixture with a small wad of cloth:

Boiled Linseed Oil	4 oz.
White Shellac cut in Alcohol	2½ oz.
Spar Varnish	1 oz.
Venice Turpentine	10 drops
Oil Cedar Leaves	20 drops
Oil Soluble Red	To color

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Oil soluble red is a dark reddish black powder sold by large drug stores and chemical houses—it is the same material used to color motor gasoline by companies wishing to get three cents per gallon more for their product. A quantity of this powder the size of a match head will color a half pint of oil or any oil mixture a brilliant red. This red in a stock finish merely imparts a rich glow to the wood without actually staining it red. It may be omitted if desired, or if the wood has a pronounced reddish cast, use alcanet root instead. This usually comes as a vile smelling powder, and should be mixed with the linseed oil before other ingredients are added. Warm the oil, and let the powder remain for two or three hours, then strain.

Venice turpentine is a thick substance harder to pour than molasses in winter. Violin makers add it to varnish to prevent cracking. It is advisable to use a few drops of it in any stock mixture containing varnish and it also helps to seal the pores of the wood.

This mixture quickly sinks in and penetrates, and should be allowed to set 24 hours before any further finish is applied. Some stockers merely coat the stock with thin shellac after the first oiling, and this is a desirable practice on extremely open grained wood. When it dries, it should all be lightly sanded from the surface before you proceed with the oiling.

Hard, close-grained wood with small pores may be sealed with this mixture:

Raw Linseed Oil	½ pint
Spar Varnish	2 oz.
Turpentine	1 oz.
Venice Turpentine	10 drops
Oil Soluble Red	1 grain

(Omit if desired, or substitute alcanet root)

Warm the stock slightly and apply above mixture with a swab, once over. Note time required for it to sink in. If the wood absorbs it immediately, it may be necessary to use the first formula given. If a lot of it remains on the surface, it is probably going to be O.K. This should be permitted to dry for two or three days.

OILING FOR FINAL FINISH. With the pores below the surface pretty well sealed, we can now expect results from our work from this point. I prefer to use either straight raw oil, or red oil (pure raw linseed colored with oil soluble red) according to color desired. Apply a light coat with a small rag or swab, and let it stand for an hour. Then rub briskly with palm of hand for ten or fifteen minutes. Set the stock up with a thin coat of oil on surface, but not running or dripping.

Repeat this treatment at 12 to 24 hour intervals—every 12 hours if the surface looks dull, or every 24 hours if the oil remains on surface that long. After four or five such treatments, allow the stock to stand for a couple of days, then apply another coat of raw oil

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(or boiled oil if you want to hurry the job), set the stock away and forget it. In three or four days this last coat should be hardened and gummed over the surface—about like a coat of varnish, roughly applied, would appear.

With a small wad of rags or waste, coat the stock with hard automobile cup grease; sprinkle sparingly with powdered pumice and *scour off all the hardened coat of oil.* Grind it right down to the bare wood—you can't hurt the finish. Then rub with the bare hand. You now have a finer finish than any factory ever turned out, and the gun is ready to use if you want to, although the finish is still a little "green" and had best be allowed to dry a few days yet. Take it up whenever you feel like it and hand rub for a few moments—using a little cup grease on the hands will also help, but rub the stock until dry each time. And at the end of each trip to range or woods, rub in half teaspoonful of oil—preferably raw—with the hands.

The coating of oil that was allowed to dry on the surface completely filled the pores of the wood level with the surface. Some

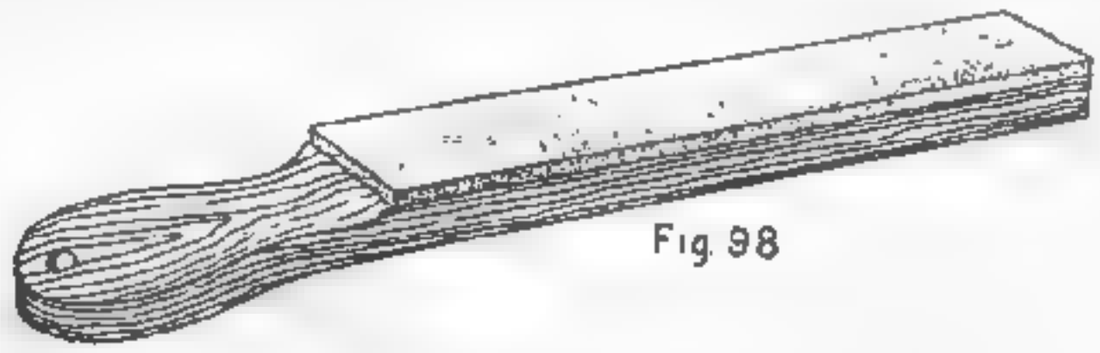

Fig. 98

finishers follow the pumice rubbing with powdered rotten-stone, using a rubbing stick (Figure 98) about a foot long with a piece of heavy leather glued on one side. The rotten stone is sprinkled on the leather, and the stick used like a file, mostly across the grain. By this method the rotten stone helps to fill the pores, but may work out in time.

Checking should not be done until all the oiling has been finished, provided time permits. It may, however, be done when only the last two or three oilings remain, if the gun is needed as soon as possible. After checking treat the stock to one more oiling, well rubbed in by hand, and when the oil has stood in the checked sections for an hour, rub it out well with a stiff bristle brush to prevent gumming in the diamonds.

The foregoing is my pet method for producing a high grade finish, when there is time for it. It involves all told four to six weeks, yet the actual labor time will not total more than two or three hours. It is the easiest, and best method I know of. Yet the time consumed prevents its use many times, when a man wants his gun within a week or so.

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For a speedy job, and a very good one at that, proceed as follows: First oiling same as with previous process; then apply one coat of natural wood filler, thinned with turpentine to consistency of thin cream; let this dry an hour, then rub off with burlap; let stand till next day, then apply one coat of raw oil, rubbed in vigorously with bare hands. Wipe off next day, and apply spar varnish, and boiled oil, half and half. This should gum in 12 hours, and be well gummed in 24 hours. Then grind off with pumice and cup grease as before described. Subsequent oilings with raw or boiled oil may be applied as time permits.

A job may also be speeded up by alternate applications of Formula No. 1 and boiled linseed oil applied a day apart.

When a stock has had two or three oilings, and it becomes necessary to complete the finish at once, rub on a coat of pure spar varnish with a rag; the oil already in the wood will prevent its hardening, but it will gum quickly and in eight to twelve hours be about as hard as a well dried coat of oil. Grind it off with pumice, polish with rotten stone on the rubbing stick, then polish with Formula No. 1 on a rag, using it just as you would furniture polish. Conclude with a brisk hand rub with a few drops of boiled oil.

Sometimes, when stocks are very soft, I find the following procedure desirable: Coat with boiled oil and let stand until oil begins to set; then delay setting by rubbing in hard cup grease. Wipe off dry in 12 hours; and apply boiled oil, and repeat process two or three times.

When an oil finish has been completed, it is always improved by a light coat of cup grease rubbed all over it. This grease should be wiped off and stock rubbed with the bare hand before using the gun.

In refinishing old stocks already checked, exercise due care to prevent the oil running into the checked portions and gumming there. After each oiling, scrub out the checking with a stiff brush to remove surplus oil, and after the job is completed, retrace all the checking with the V tool, then oil lightly and brush out clean.

The time honored method of finishing a stock by 10 to 50 coats of oil laboriously rubbed in by hand often produces a fine finish; too often, however, it results in building up an outer skin or coating much like a coat of varnish, which shows finger prints, and which will sometimes be seriously damaged by a heavy rain or by immersion. And in many cases it results in the wood absorbing so much oil that much of the grain is hidden and the wood is turned almost black.

There is no reason, traditional or otherwise, for a black or very dark stock. A rich deep brown, with perhaps a slight reddish cast, with the dark and light portions showing in pleasng contrast is, to my mind, the most beautiful stock of all. If you want it black, you can paint it.

VARNISHING STOCKS. Some people think that the only way to finish a stock in a hurry is to varnish it. Personally, I see no

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excuse for a varnish finish in any case, since I can, by one or other of the methods above described, turn out an oil job about as quickly as a good varnish job, if speed is needed.

Nevertheless, varnish is the thing on some woods other than walnut, and since it is occasionally preferred for walnut by some, a few remarks on varnishing are in order.

After the stock has been sanded and "whiskered," as for oiling, mix up some natural (uncolored) wood filler with spirits turpentine until the consistency of thin cream. Apply with a stiff paint brush and let dry for an hour. Then take a piece of coarse cloth such as burlap, and rub off across the grain.

An easy way to hold a stock while working on it is to have a tapered stick eight or ten inches long which will rest easily in the barrel channel. Turn the stock sideways and clamp the forend in vise, using a vise block or felt or leather pad to protect the bottom surface. Now you can use your rag across the grain like shining a shoe. Another good way is to hold the stock in the checking cradle, as described and illustrated in the chapter on Checking.

After rubbing off the filler, let stand till next day, then go over lightly with very fine sandpaper. Wipe off carefully with a clean rag, and be sure there are no particles of grit or dust on the surface. Get 1/4 pint of hard rubbing varnish and 1/4 pint of good spar varnish (Valspar is good; also du Pont's spar varnish), mix the two and pour out about a fourth of the mixture, to which add an ounce of turpentine. Apply this to the stock quickly with light, long strokes, using brush fairly full but not dripping, and "flowing" the varnish with a minimum of brushing. An excess of varnish will run, causing thick places in the finish—this must be avoided. Let dry until absolutely hard. Test by pressing hard with the thumb—if it shows a "thumb print" that won't rub off, it isn't hard enough.

When well hardened, take a thick piece of felt (obtainable at paint stores), dip it into water, sprinkle with powdered pumice, and scour the varnish down to a smooth even surface. Be careful not to grind clear through, but grind off all the "pimples," of which there will be plenty, unless you have a dustproof room in which to do your varnishing. When surface is smooth as possible, sponge off with clean water, wipe dry, and let stand for an hour or so. Then take the remainder of the varnish to which no turpentine was added. Mix in just a few drops of Venice turpentine, and apply a smooth even coat. This should dry for two or three days at least, after which it should be ground as before with pumice stone and water; let stand a day, polish with rotten stone and light oil on felt. Subsequent coats may be added if desired, but will only thicken the varnish, making it more liable to crack.

Some painters prefer to use shellac instead of filler, but it tends to make a more brittle outer coat, and moreover, requires more varnish for a smooth finish than when regular filler is used.

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If commercial filler is not available a good one can be made as follows:

Powdered pumice or quartz . ...1 part
Fine wheat flour .....1 part

Mix to a stiff paste with boiled linseed oil, color with alcanet root, raw umber, or any pigments available to make it dark; thin for use with turpentine as needed. Common putty can also be reduced with turpentine and used for filler in a pinch, but it will be improved by the addition of a small amount of boiled oil and Le Page's glue.

Always use a dark colored filler on a stock that is to be varnished, and a white filler when stock is to be oiled. The oiling will darken the filler, but the varnish will not.

Cherry, Maple, Apple, and other dense woods, or woods that have been stained should receive one or more coats of varnish without any filler. The varnish should all be ground off the surface, leaving it only in the pores. Then a third coat may be applied and ground down very thin, after which such woods will take a nice finish with boiled or raw oil.

Mahogany and similar open grained woods soak up so much oil that it is almost impossible to complete the job. The better plan is to use filler and varnish, applying several coats and grinding each coat down thin; after which apply Formula No. 1, using it like furniture polish. Mahogany and oak are about the two meanest woods to check that I know of

Once in a while one can get hold of a piece of African Rosewood, and it makes one of the most beautiful stocks imaginable, although too showy for some people. This wood is naturally very oily, and its first treatment should be pure turpentine, which is allowed to dry 12 hours. Then use only boiled oil, and use it sparingly. Rub it in by hand, and grind it off with pumice if it commences to coat the surface. You will secure a beautiful finish very quickly. Rosewood is a little brash for stocks, and would scarcely be selected for guns with heavy recoil, but it takes the checking better than any wood I know of.

LACQUER. Here is the quickest finish of all, and would undoubtedly be more popular if it were better known. In addition to du Pont's clear brushing lacquer there are several other brands almost equally good. No filler and no preparation of the wood are needed, except sanding and whiskering. Support the stock by the ends so that you can work all around it (set it up in the checking cradle if you have one); thin the lacquer 20 to 30 per cent. with the thinner recommended by the maker, and spray it on with a painter's air-brush or with one of the commercial hand sprayers sold for two to three dollars. There's a knack about using one of these sprayers that must be acquired by practice, but once you get it you'll never want to

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use a brush again. A lacquer stock will be dried hard and ready to use in 30 minutes to an hour and the finish will be water proof and nearly all other kinds of proof. It will look for all the world like varnish, but lacks all the disadvantages of varnish. A second application may be used, but is seldom necessary. If you object to the shine, the finish may be dulled by rubbing down with pumice stone and water, using plenty of both.

Lacquer may be used over a stained stock, but not one that has oil in it. It works best on clean, dry bare wood. It is a thoroughly practical finish, but will not bring out the beauty of the grain as an oil finish does. Nothing will.

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Chapter 14

REPAIRING AND REMODELING STOCKS

PERHAPS the gunowner may hesitate at re-stocking his gun until experience with tools has given him a measure of confidence. Remodeling an old military stock, or a factory stock, to give a better fit and to conform more nearly to our present ideas of stock design will not only provide excellent practice with tools but will often result in a mighty practical, good looking stock. The job of course calls for far less work than the making of a new stock, and the tedious, particular job of inletting barrel and action is entirely avoided.

The stocks on most military rifles are extra thick and heavy in all their dimensions with the exception of length, and these may often be considerably improved by merely working them down to more comfortable and pleasing size. Sometimes one can take advantage of this extra thickness of wood to do a little re-shaping to improve the handling of stock. An example of this is the Krag stock, which has very little comb. Yet the grip just ahead of the comb is very thick, and will stand some reducing. By cutting down the grip just forward of comb,—in other words, deepening the "hand hole"—the comb is made to appear higher. Thus we take advantage of the grip's thickness by doing all our reducing on the top and sides, and none on the bottom.

Since we have mentioned the Krag, we will take this as an example of what may be done in complete stock remodeling. The Krag stock is longer than the Springfield—in fact, it is a fairly good fit for most shooters "as issued." The comb is too low, and sets too far back; the trip is too thick; it lacks a pistol grip; the butt can stand considerable thinning, also re-shaping, and the fitting of a better butt plate, or a rubber recoil pad.

INLAYING COMBS AND GRIPS. Figure 99 shows what

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may be done in the way of re-shaping the Krag butt stock to give any desired shape and dimensions. The dotted lines show the original shape of stock, while the heavy lines show its final shape after remodeling. The thin solid lines indicate saw-cuts made in the original stock, to which larger pieces of walnut are fitted. The first cut is made in upper side of grip about 1/2 inch ahead of where you want the point of comb to be located. This cut is from 1/4 to 3/8 inch deep, and slopes forward slightly toward the bottom. With the rip saw a cut is made starting at a point on the butt from 1 to 1 1/8 inch below heel; the cut goes forward to meet the first cut. It is advisable to make the saw cut 1/16 inch outside the line, and work carefully down to the line with a cabinet file. Then with file and scraper, work this edge into a perfectly straight line, and scrape out the center of the flat surface to a *very slight* hollow from side to side of stock. Now cut a piece of walnut to fit, leaving it considerably higher than you want the stock. Fit this very carefully with file and scraper, spotting the two surfaces together with blue chalk. Rub the chalk thickly on one surface, then place the other piece against it, and rub back and forward slighely. Then scrape off the spots left by the chalk until the two surfaces are in perfect contact at all points. Be sure to get a good fit at the forward point. Now slightly hollow the surface of the piece being fitted—just a light scrape or two is sufficient. Bore two 3/8 inch holes in stock at the positions shown, for dowel pins. Coat the wood around the holes with dry lampblack. Press the piece into place, so as to get an exact imprint of the holes. Find and mark the centers of these imprints, then bore the holes *about 1/64 inch off center, toward the butt, in this piece.* This causes the dowels to "draw" the piece forward to a very tight fit at the point. Now cut the dowels from a regular hardwood dowel rod, and fit them into the stock, using hot white flake glue. Cut them off so that they project from 3/8 to 1/2 inch, and bevel the ends slightly. *Now work fast*—coat edge of stock and edge of new piece with the hot glue, set the piece in place, force it down on the dowels, and clamp tightly at a point about two inches from each end. Use cabinet-makers' "C" clamps, or if you have a very wide vise, the clamps need not be used. The main thing is to get plenty of pressure, so as to squeeze the glue out of the edge, leaving wood touching wood, with no line of glue between. Let dry for 48 hours.

For a pistol grip, saw the stock at right angles to grip, at a point about 3/8 inch back of end of guard. This cut should be from 1/4 to 1/2 inch deep, depending on the fullness of original grip. The cut must be carried far enough up the curved side so as to provide the full thickness desired in new grip. The common mistake is to make this cut too shallow, making it necessary to flatten the grip like a board when shaping it up. These old stocks are usually of strong, straight grained walnut, with an ample margin

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of strength; and they are not materially weakened by inlaying pieces in this manner, especially if the pieces fit tightly at both ends, thus taking up the back thrust of recoil.

The rear cut should be made exactly where the rear end of pistol grip is to come, and should extend from 1/2 to 11/16 inch into the stock. To locate the position of this cut, lay out an outline of the old stock on paper, then mark out on it the curve and shape of the desired grip, giving the bottom of grip a length equal to the long dimension of the grip cap you purpose using. From 1 3/4 to 1 7/8 inch is about right.

Saw out a block of good sound walnut so that the grain, when shaped into a grip will run well in line with the grain in the stock. By careful selection it is often possible to match the grain. Trim out the wood between saw cuts in stock with a flat chisel, cutting and scraping the bottom of cut to a good straight line—cut a piece of hack saw blade the right length and use it for a straightedge. Scrape the center of this surface to a very slight hollow. Now lay the stock over the block you have prepared, and carefully mark the shape of this dovetail on block with the point of a knife. Do not cut the block quite to the line at first, but fit it carefully and slowly into stock. Chalk the surface of dovetail and start the block in as far as it will go, then work off the chalk smudges as required. It should be a light driving fit, and should always be pushed in and withdrawn from the same side. As you approach the final fit, file the saw cuts at end of dovetail in stock to a *very slight taper*, so that the further in the block is pushed, the tighter it will fit. Now coat both surfaces with hot glue, drive in the block—being careful not to drive hard enough to split the stock. Just a good snug fit is what you want. Then clamp stock in vise for 48 hours, setting up the vise until the glue squeezes out of the edges.

In using hot glue, it is important to get the work clamped within a few seconds from the time glue is applied. It starts to cool and set very quickly, and the difference between a perfect joint and a shoddy one that will sooner or later break depends on getting the two parts together and under pressure without loss of an instant. The right kind of a glued joint is invariably stronger than the solid wood around it—the wood usually breaking under strain before the joint will let go.

If desired a dowel can be put in through center of pistol grip, but it is not really necessary. The best plan is to use a grip-cap screw long enough to reach 1/2 inch past the joint. The hole for this screw should be larger than the threads before the joint is reached, so that only the threads that are in the stock itself do the holding. Thus the strain constantly draws the two pieces together.

RESHAPING BUTT. Next comes the shaping up of the butt, which shape of course will be governed by the shape of your butt plate. If you have a good shotgun type butt plate it will be nearly

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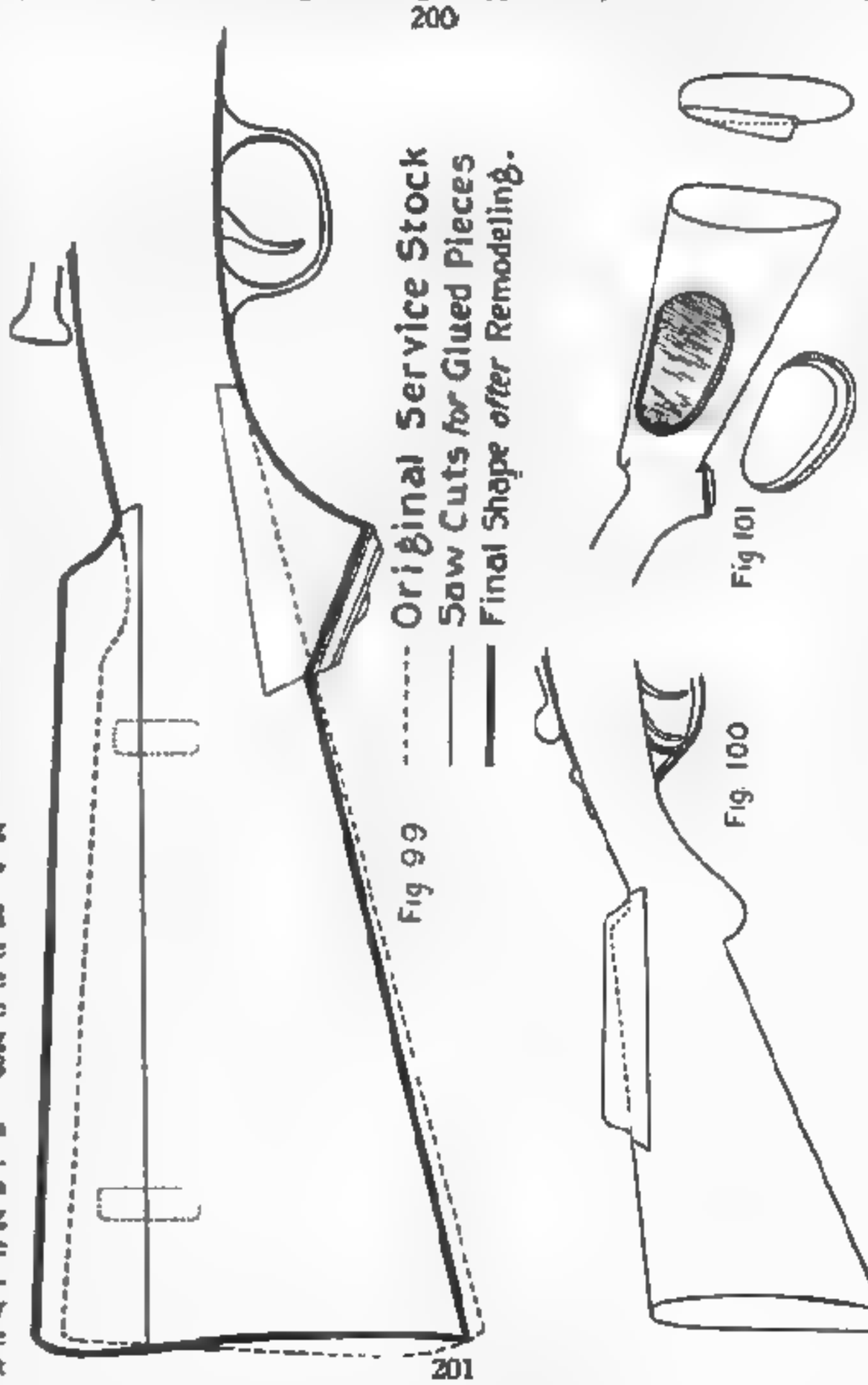

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as wide, perhaps, as the service plate. However, the butt will very likely have enough thickness to spare to enable you to give the stock a little castoff if desired. (See Chapter 9.)

First rasp off the end of piece glued on top of stock, and work down the butt from heel to toe to approximately the pitch desired—remembering that most buttplates are thicker, or have a slight

hump at heel, which increases the pitch. Then find exact center of stock and mark a line from heel to toe. Now if you want castoff, mark the castoff center as described in Chapter 9, and run a line from this point to center of upper and lower edges of grip, just back of tang on top, and just back of guard on bottom. If no castoff is wanted, merely run the lines in exact center of stock.

The fitting of the buttplate or rubber recoil pad, and the shaping up of stock, are done in the same manner as for a new stock—the difference being that in this case there is less work. All of the remaining surface of the old stock should be filed off a trifle, as the wood is likely to be well soaked with oil and grease, and a fresh clean surface is desirable for the new finish. Moreover, oiled wood does not sandpaper very smoothly, but remains "fuzzy" regardless of the time spent on it.

If a grip cap is used, fit it as soon as the grip is roughed nearly to size, then work to the edges to get the final shape.

There have been some fearful and wonderful suggestions for stock remodeling contained in various magazine articles, from time to time. One man, I recall, said he fitted a small wedge-shaped piece of walnut to the toe of the Krag stock, where it is rounded off. It may be that he was able to do a good job and make the stock look like something, but personally I don't care for such tricks. If the grain of such a piece runs with the grain of the stock, it is almost sure to split sooner or later— and probably sooner. Moreover it will look just like what it is—a patch. And finally there isn't one man in a thousand who could fit such a piece without having the paper-thin edge chip or break, leaving a small gap under the buttplate. The thing to do if you want to get rid of this rounded toe—which incidently is not a bad thing, as it prevents the toe of stock cracking off when struck on the ground, is to shape the butt as shown in Figure 99, which gives four or five inches pitch, and is mighty comfortable either offhand or prone. If this makes the stock too short, a recoil pad can be used to lengthen it up to 7/8 inch, or one of various other methods may be used.

LENGTHENING STOCKS. One way to lengthen a stock is to cut a walnut block, with the grain running in the direction of the stock, fit and glue it to the butt, which has first been sawed off square and the surface accurately finished. I am unable to consider this at all good practice. First, it looks like a patch, which it is. The grain cannot be well matched, nor can a good joint be made. Due to the grain running the short way of the block it is difficult to get a per-

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fect glueing surface, and when sufficient pressure is applied for a glued joint, the block will likely crack. Nevertheless, this practice is often followed, so let your conscience be your guide. Use the "C" clamp or the fork clamp illustrated in Chapter 4 for clamping the block in position, and have a hardwood block under the setscrew.

Sometimes layers of heavy leather are used to lengthen the stock. This makes a fairly good looking job, and also makes it easy to fit the butt plate, because there is a certain amount of "give" in the leather. The pieces should be cut a little larger than the butt; coat both sides of all but the outside piece with du Pont Cement, and clamp in position as already described. Let dry 48 hours or longer. Then fit butt plate, using file and sandpaper to shape the leather butt, attach plate, set the screws up tight, then buff off leather on sandpaper wheel, as described in Chapter 11 for fitting rubber recoil pad.

Another material that may be used in the same manner is fibre. Strips of red and black fibre cemented alternately give a good appearance and look less like a patch than leather. Moreover, they take a better finish. The linseed oil used for finishing the stock does not do so well on leather, so that it is necessary to do a lot of extra rubbing with shoemaker's "heel ball," beeswax, etc., to complete the finish on the leather—then it will be rough most of the time. No special treatment is needed for finishing the fibre—just sand and oil it when finishing the stock.

A butt extension block may also be made by glueing up thin layers of various colored woods—maple, cherry and ebony, for instance, and this may be fitted and glued to the butt, giving a very good appearance.

When fitting the piece to upper edge of stock from which the comb is shaped up, be careful about holes in the butt. In some rifles these will be so close to upper edge that you will saw into them when making the cut for this piece. In that case it is advisable to measure the holes and turn up walnut plugs to a tight push-fit and long enough to fill holes completely Don't get them too tight Coat them with hot glue, apply glue in the holes, and drive in the plugs. Afterward the stock may be recessed as desired for a trap butt plate.

PATCHING. I have often seen instructions for building on pistol grips which recommended hollowing out a block of walnut to fit the round side of the original grip. I don't like this for two reasons. First, because the correct fitting of the round surfaces runs into more time than anyone is willing to pay for; and moreover, due to the oil in the wood, the glue joint is going to have mighty little strength, requiring a long screw or a dowel to make it secure, and even then it will probably come loose in time. Finally, the feathered edges of the false grip where they join sides of stock, are bound to show, even if the grip is checked. It's just contrary to the laws of woodworking to get a good joint in this manner. If

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one feels that the dovetail method is likely to weaken the stock, he may use the other way if desired; but I never knew a stock to break because of a dovetail grip.

When shaping up a stock on which a false comb has been glued it may prove necessary to undercut the comb slightly (See Chaper 9), as the original stock is not very thick at that point, and the piece may have a square edge showing after shaping to required thickness. Undercutting here brings the surface smooth and also helps the appearance of stock.

The foregoing will apply to a number of stocks having straight grips, when it is desired to have a pistol grip. Some rifles have a long tang extending back of trigger guard, and on such the practicability of fitting a pistol grip depends on the type of action. If the tang is merely to strengthen the trip it may be bent to the desired curve, then the grip dovetailed in, and tang inletted into it, thus adding strength. Quite often some of the action springs or other working parts are attached to this lower tang, in which event some careful study is advisable before attempting to change its shape. An example of such a job will be found in the description of the remodeled Single Shot Winchester described in Chapter 30. Chapter 24 also gives detailed instructions for bending tangs, and making necessary inside alterations.

The shotgun owner whose stock has a pistol grip back under the middle of stock where it does no good, may decide the stock would look better with a straight grip—and usually his decision is the right one. It is quite easy to make the change. Set the stock in the vise and saw off the grip, then use the cabinet file to round off edges to conform to the lines of stock. Be careful not to file further into the checking than necessary. Carefully sandpaper the bare portion, then straighten out the tang of trigger guard. Most shotgun guards are made of soft iron and may be re-shaped cold. Use a smooth faced hammer, and rest the guard on a steel, iron or brass bench block with a heavy leather on it. When the tang is the right shape, screw in the guard, then inlet the tang into the stock, as described in Chapter 10. Finally refinish the bare spot and check the grip, following the lines of the original checking as far as they go, and using a checking liner *exactly* the same width as the original diamonds. Don't try to get by with a liner that is *almost* correct,—your checking will come out all galley-wampus. If you haven't the right size liner, make another.

REFINISHING. Any stock having an oil finish may have any part worked off or reduced in size; after which the bare spot may be finished to match the balance of stock perfectly. Just follow instructions for finishing new stocks, doing most of the oiling on the bare spot, and then working on entire stock as the finish nears completion. Altering or cutting down a varnished stock necessitates, or should necessitate, complete refinishing. Some gunsmiths would rub over the spot with oil and shellac, or try to "splice" the varnish. To do the job right, remove all the old varnish, prepare the stock for a new finish, and oil or varnish as desired.

The trapshooter may take a notion he wants a Monte-Carlo comb on his gun. No reason why he can't have it. Cut down as shown in Figure 100, make and fit the block in same manner as the grip was fitted in Figure 99—that is, slightly wedging the dovetail. Drive in the block snugly with plenty of hot glue, let dry a couple of days, and shape up as required—then refinish stock. In this instance it will probably be impossible to carry the comb forward very much as most shotguns have upper tang extending back nearly to the comb. This

job should not be attempted on any gun like the Winchester hammerless pump, or the Remington or Browning Automatic, or any gun having an attachment screw running through the grip from the butt, or any part of the "works" such as recoil springs, etc., located in the grip.

INLETTING CHEEKPIECE. Making and fitting a cheek piece to a stock originally made without one is a job no one need be afraid of. Select a piece of walnut matching the stock in grain and color. Cut it to size and shape desired, leaving a base portion about 1/8 inch thick at lower edge, and 1/4 inch thick at upper edge. This piece may be practically finished around the edges before any work is done on the stock. Lay it in position on stock and mark around it carefully with knife point. Cut out the seat in stock, removing more of the wood at the upper edge than at lower edge of recess. Fit the cheek piece into this depression with chalk, spotting both surfaces into perfect contact. Use hot glue, and leave the stock clamped for 48 hours or longer. Then round off upper edge to conform to lines of stock and shape up cheek piece on surface as desired, then refinish entire stock. Fitted in this manner there will be no visible joint except along top edge of comb, and if the wood matches and the fitting is carefully done, this will be well-nigh invisible. Figure 101 shows the method of fitting the cheek piece, also a sectional view of the stock recess. No dowels, screws, pins or nails are needed if your glue is good and the fitting properly done—there is no strain on a cheek piece.

REMODELING BUTTPLATES. The question of a suitable buttplate usually comes up when remodeling a military or factory-made stock. Military buttplates were designed—apparently—for making dents in the armory floor. However, the military plate may often be remodelled as outlined in Chapter 24, which also describes the making of special buttplates.

The Mannlicher-Schoennauer buttplate is almost ideal in shape and size, and has the very desirable long trap for cleaning materials. For strictly offhand shooting it is ideal. Many, however, find it unsuited to prone shooting, as it is more deeply hollowed than the shotgun plate, and has considerably more "hump" at the heel. This

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plate may be purchased from Von Lengerke & Detmold, of New York City. The Mauser sporting type buttplate is even better designed and better made. It is a heavy drop forging, and the trap is set in on a square milled cut around the edges of the hole, instead of being merely bevelled. It is a trifle smaller than the other, being barely 5 inches long, which will take it out of the running for those demanding the largest plate obtainable. The Mauser plate may be had from A. F. Stoeger, Inc., New York City. The Mannlicher-Schoennauer plate has deep cross corrugations, while the Mauser plate is smooth It may be corrugated or checked, or may be given a sharp matted surface by stippling, as described in Chapter 19. This, to my mind, is the best way to roughen up a buttplate. It takes mighty little roughening to prevent a steel plate from slipping on the shoulder. Some insist on having deep coarse diamond or square checking on it, or very deep cross corrugations, in the belief that anything else will slip. I like to shoot with as few clothes on as possible—particularly as little as possible on my right arm and shoulder. And I have come in with the print of a very rough buttplate clearly stamped on the skin of my shoulder and the blood showing through—this through an O. D. Shirt and underwear. Such a rough buttplate will stay put not one bit better than one with almost a smooth surface, and is far easier on the shoulder. Fine diamond checking or cross scoring or fine stippling only are needed.

RE-SHAPING FOREND. Re-shaping a military forend into one more suitable for sporting use is generally easy because there is plenty of extra wood to work on. The different kinds and shapes of forend tips are described in Chapter 9, and one may work out almost any shape desired, so long as it is not larger than the original forend.

Fig. 102.

Even then it is entirely practicable to square up the sides, dressing off enough of the original wood to get rid of the oil, and glue on slabs which are later worked down into a beaver-tail forend.

One may object to the hand-grooves along the sides. These can be removed by cutting them out to a wide V-shape as shown in Figure 102, then planing down strips of walnut to match and glueing them into the grooves. This is much easier and makes a better joint than trying to fit pieces into the round grooves, and it also gets rid of the oil, so the glue will hold. Use hot glue, and lay a strong

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strip of wood over each of the strips, then clamp in the vise for 48 hours before shaping. The strips should be spotted in with chalk, same as other patchwork, and don't depend on the glue filling up any gaping edges, because it won't. The instant the checking tool hits it, it's out. Fit the strips tight at all points.

Most military stocks have deep channels cut in the forend under the barrel to lighten the stock. Usually cutting the forend to sporting length exposes one of these at the end. This one must be filled to make a good job. I usually use a piece of solid wood from the same stock, taken from the muzzle end where there is no channel —this gives a piece of walnut that will match. Square this piece

Fig. 103

up to a snug sliding fit in the hollow under barrel at muzzle. Coat it with hot glue, or du Pont cement, also coat the inside of hollow. Slip it in place, and clamp in the vise from side to side, also use a small clamp from top to bottom. Or, place a round stick on top in the barrel channel and clamp from top to bottom of forend in the vise, using a hand clamp against the sides. When dry, cut the heads off four small cigar box nails, and drive them in, two on each side, sinking them well below the surface. When the stock is sanded and oiled the holes will close up and will not be noticeable.

The barrel is held to the forend by the original outside band, or by one of the inside bands described in Chapter 24, according to the design of your forend.

REPAIRING BROKEN STOCKS. Sometimes—but not often —a broken stock can be repaired to make it as good as new, and as strong. Usually a new stock is indicated. Since no two breaks are exactly alike, the exercise of a little ingenuity is usually required to decide how to make the repair and whether or not any repair is practicable.

Stocks of bolt action rifles, if they break at all, usually break across the grip as indicated by Figure 103, or else split vertically

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back of the tang screw. The former is caused by improper selection of wood, so that the grain at grip runs downward toward the guard, or by too small a grip, or both. The split back of tang is caused by incorrect inletting of the action, leaving it too tight against the wood on sides of receiver, especially toward the rear where the tang tapers;—this, and lack of support against the shock of recoil thrust.

A grip broken like Figure 103 always calls for a new stock. It may be repaired to give service for a time, however, by coating both surfaces with hot glue or du Pont cement and clamping together under heavy pressure. Then put two brass wood screws in each end, drilling the holes carefully to avoid further splitting. Then wind the entire grip tightly with copper wire, using about No. 24 gauge size. Fasten the wire at beginning of winding by laying the end under five or six turns. Wind on evenly and smoothly over the entire break, then fasten the end by holding tightly and running on solder for about an inch to hold it to the last winding. Cut off, leaving about an inch project, and force this under the windings. Coat the wire all over with solder, working it well

in between the windings with the soldering copper, uniting the wires into a solid covering. Then dress off the surface smoothly with emery cloth. A repair of this kind will occasionally prove as strong as the stock was originally, and equal to it in all respects except appearance.

Once in a while some maker will let his enthusiasm for beautiful grain run away with him to the extent of making a stock with curly cross grain at the grip. I was recently called on to repair a broken grip like Figure 104, which shows the direction of the crack on both sides. The grain ran almost at right angles to the grip, and the break had followed the grain, extending almost to the bottom on right side, and about half way down on the left. This was a high grade English 8-bore, and it was desired to make a permanent and invisible repair if possible.

After removing the action from the stock, the latter was held tightly in the vise, with felt covered blocks gripping the grip just back of the crack. A red fiber block was then laid in the upper tang channel, and vigorously hammered until the forward portion broke off, the crack continuing in an angle forward through bottom of lock recesses. Various trials showed that there was no way to hold the parts together with clamps, and that only the action itself would hold them. Both of the broken surfaces were then slightly coated with du Pont cement, which was allowed to dry a few minutes; they were then placed together and the action parts fitted, with a layer of blotting paper under the tangs to provide extra tension, then the screws set up as tightly as possible. The edges of tangs were lightly greased to prevent the cement sticking where it oozed out. The stock was left without touching for nearly a week, then the action

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removed and the repair tested by putting a block of fibre in upper tang channel and hammering, as when breaking off the piece. When the stock showed no signs of letting loose under some pretty vigorous blows, it was decided the job might hold. Then to further reinforce it, a round-head brass wood screw 2 3/4 inches long was turned in as shown in Figure 105. The hole for this screw was drilled starting just below the lock plate shoulder in extreme rear of lock

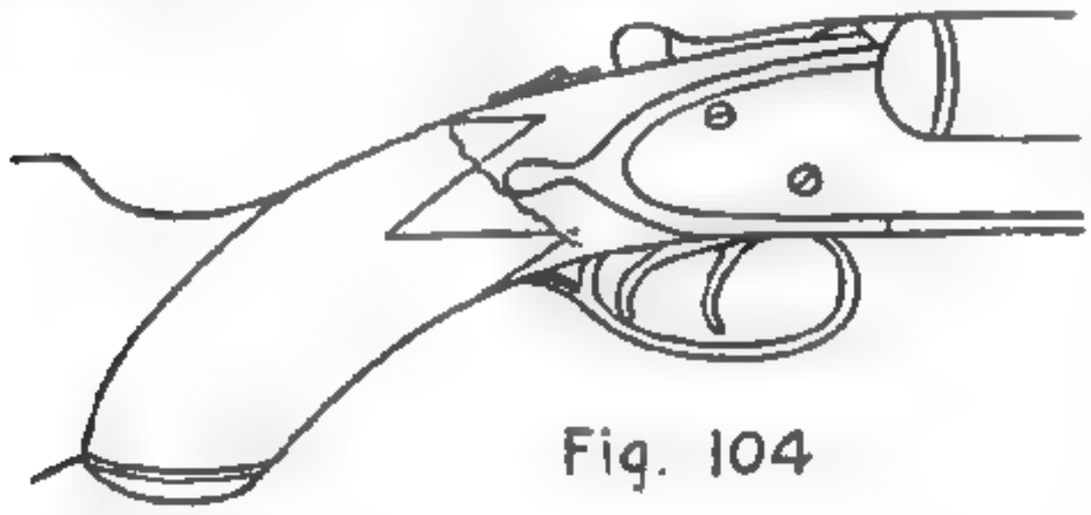

Fig. 104

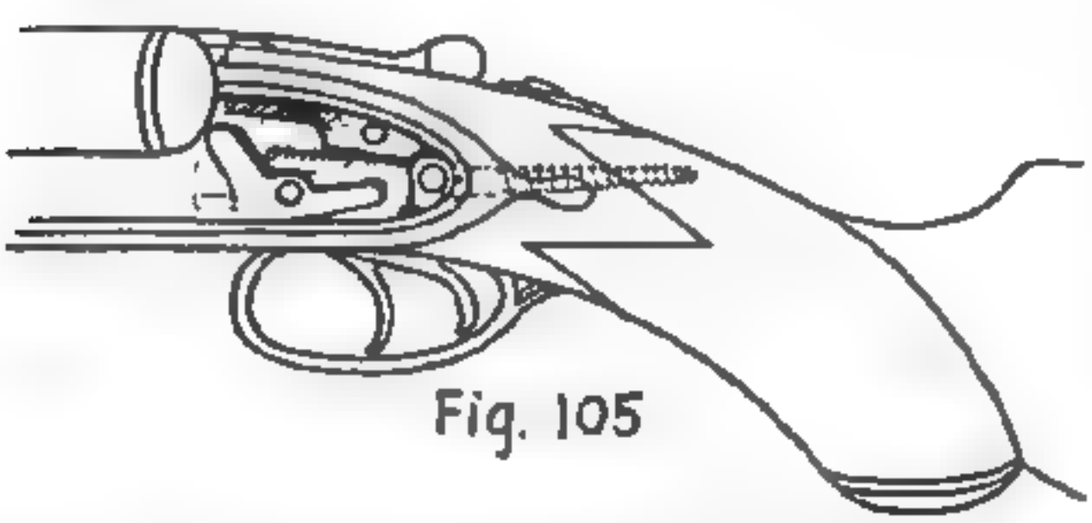

Fig. 105

recess, running back at a sharp angle almost in line with the stock and nearly at right angles to the break. Outer end of screw hole was drilled body size, the threads being allowed to take hold only in the inner end of hole, to give a good draw. This screw was then turned up very tight. Then the surplus cement was carefully scraped from the edges of the break, and the wood dressed down on edges where they showed on bottom under the action recesses by scraping and fine sandpaper. Most of this break had occurred in the checking of the grip, so all the checking was completely retraced with the V tool after the stock had been re-finished. I don't know whether this repair held, but have heard nothing to the contrary from the owner to date. I would expect it to hold indefinitely.

Because of the perverted ideas of some factories with regard to

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pitch and shape of buttplates, splitting off the toe of a stock is a common occurrence. It doesn't take much of a blow when dropping the gun on the butt to split off a piece two or three inches long. The ideas of some mechanics relative to repairing such breaks is occasionally startling. A Model '99 Savage was brought to me recently on which a broken stock toe had been repaired by drilling a hole through the butt edgewise, from heel to toe, through which a long stove bolt had been inserted. The nut had been set up tightly with a washer under it, and the end of bolt peened or riveted to keep the nut from coming off. When I called the owner's attention to the fact that the stock was loose and wobbled on the receiver, he asked me to tighten it, and was quite surprised when I told him there was no way to get a screwdriver in to the butt screw past that stove bolt! After several futile efforts to slip the screwdriver past the said bolt, he instructed me to make a more satisfactory repair, which was done by grinding off end of bolt and taking it out, gluing on the broken toe, and reaming out and plugging with walnut the holes in toe and heel, then refinishing stock.

INLAYING AND PLUGGING. Plugging holes in this manner is a job requiring some care. The holes should first be cut out true with a Forstner bit. Then turn the plug to exact size, making a snug fit but without enough pressure to cause splitting. The easiest plug to make is of course the one with end grain exposed, but it is more conspicuous on the stock. To make a plug with side grain exposed, screw a piece of pine onto the face plate of the lathe, and on this glue a 1 inch thick piece of walnut. Set the tool rest across the bed, that is parallel to the face plate's surface, and turn the plug from the end, same as when turning a disk; then cut off to the required length. Half an inch is plenty in most cases, and the grain may be lined up with the grain of stock, then, when oiled, will take the same finish and be almost unnoticeable.

Small inlays are easily made from walnut, bakelite or fiber to fill up recesses left by removing swivels and the like. To get the shape required, coat the stock around the recess with dry lampblack, press a piece of white paper over it, then trace the impression on the piece from which the inlay is to be made. Shape up the inlay carefully, with a file, trying often for fit, and tapering the edges slightly. Coat inside of stock recess with du Pont cement, also coat bottom and edges of inlay; press into place, cover with paper, and clamp in vise. when using the vise for clamping, if the jaw is not swiveled to turn at an angle, make a wedge shaped piece of wood to give the required fit to parts being clamped.

Sometimes in remodeling rifles—the Krag is an example—it will be desired to use the handguard in order to cover sight screw holes, or rough places on the barrel. Figure 106 shows a method of remodeling a handguard. The rear sight hole is cut to a dovetail, into which is fitted a thick block of walnut. Coat edges of dovetail and bottom

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of block with du Pont Cement, slide the block in tightly, and clamp in the vise with light pressure. When dry, the projecting top of block may be held in the vise while inside is dressed out with a hollow chisel to conform to the curve of barrel channel. Then, holding the block in vise so that handguard stands vertical, saw off

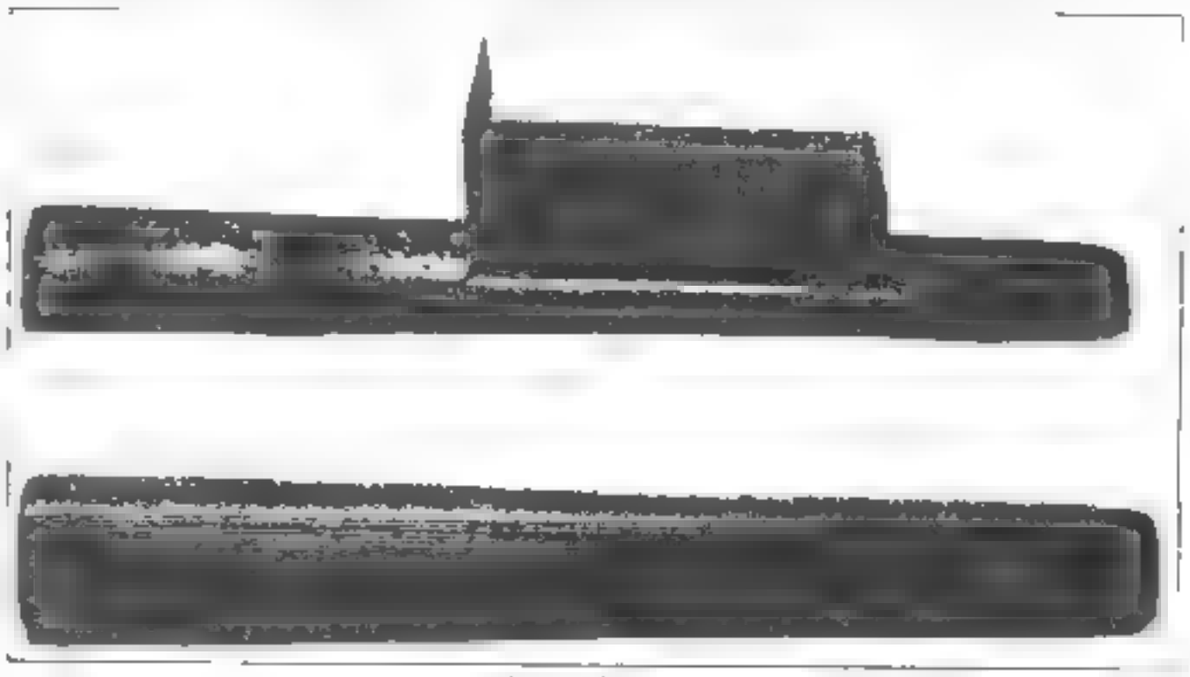

Fig. 106

excess wood, snap handguard into position on rifle, and round off top of patch with cabinet file. Smooth up with sandpaper and oil to match rest of guard. This job will be further improved by checking the upper side of guard in a strip half an inch wide, or by scoring it lengthwise with the line spacer.

SPLIT GRIP. When a rifle stock is cracked at rear of tang, the best thing to do is to get a new stock. A temporary repair may be made by forcing the crack open as far as possible with a thin bladed chisel, and squeezing in some du Pont cement. Clamp stock firmly in vise until cement dries, then drill through stock from side to side and insert a 1/8 inch brass screw. Countersink the head, and also countersink on other side and set up a small nut as tightly as possible. Cut off end of screw and rivet slightly to prevent nut turning. If a high power rifle having considerable recoil it is advisible also to wrap the grip with wire, and solder the wire, as already described, or at least to wrap it tightly with surgeon's adhesive tape. A roll of this tape an inch wide should always be carried in the field kit for temporary repairs.

After repairing the break the next thing is to remove the cause. Don't expect a stock to fit if the action is able to exert a splitting effect every time the gun is fired. First scrape the inside of all action cuts clean, then coat the action with lampblack and oil and fit into place. Relieve all pressure at sides, particularly the rear, by cutting

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out wood, just as in fitting the action into a new stock. If the smudges indicate the recoil lug has not a good bearing against the shoulder in stock, insert a metal plate as described in Chapter 10. Then assemble, and set up the screws very tightly. In doing this be sure the screws are not too long so that their points bear against bottom of hole, stop them before they are exerting pressure on stock. If such is the case, grind or file off the points sufficiently to give them good tension.

Stocks having small splits lengthwise can sometimes be permanently repaired by breaking them entirely apart at the splits, and gluing, either with hot flake glue, or with du Pont cement. For small surfaces I find the latter best, while I like the glue for large joints. The pieces must be broken apart carefully, with due care not to bruise the edges; also, take care not to lose any small splinters that may develop. They should be kept in position, leaving one end of splinter attached if possible. They must be coated all over with the glue or cement, and worked carefully in their place before the parts are clamped. Perfect contact and tight clamping are the secrets of good glued joints. Merely "pressing parts firmly into place" as the directions say, or binding with twine, will not answer—get a hundred pounds or so pressure on them, and leave it a while! *The more of the glue or cement you can squeeze out of a joint, the better and stronger the joint.*

REMOVING DENTS AND NICKS. Stocks that have been badly marred by an accident can often be brought back to new condition by careful treatment. Examine the places and decide whether they are merely dents, or whether they are nicks. If no wood has been gouged out, dents can easily be raised up even with the surface. Fold several thicknesses of cotton cloth, wring it out in water and lay over the spot. Take a hot flatiron and rub it over the cloth, wetting the cloth and repeating again until the dent is raised level. This will do for shallow dents. For very deep dents, take a can holding a gallon or so and having a tight fitting lid. Punch a hole in lid and solder into it a small piece of brass tubing, over which slip a rubber tube long enough to handle conveniently. Make a nozzle from a six inch length of brass tubing fitting tightly into the rubber. Pinch the outer end together and solder, then drill a 1/16 inch hole in one side near end.

Fill can two-thirds full of clean water and set it on the fire. When it starts boiling, pinch or clamp the rubber tube until you have a pretty good head of steam. Then turn the small jet from the nozzle into center of dent. Work it round over the sunken spot, lightly tapping the wood around dent with a small, smooth hammer. It may take several cans of water to do the trick, but dents which look utterly hopeless can be raised in this manner, which is employed in furniture stores to recondition pieces damaged in shipping. The more steam pressure you have the better. A good "corn" still of heavy

[illegible]

[illegible]er, with a strong screw cap, would of course be better than the can I have described.

Steaming out a dent by either of these methods will not hurt an oil finish except at the place where the steaming occurs. The spot when dry should be smoothed off with very fine sandpaper, and re-oiled until it matches the rest of stock. A varnish finish will of course be ruined by the steaming, and that is a good time to decide to remove all the varnish and oil finish the stock.

Sometimes a stock will be gouged or scratched on barbed wire, sharp rocks, etc., and of course when wood has been removed, no amount of steaming will level the surface. Very slight scratches and nicks are best removed by rubbing out with fine sandpaper, then refinishing the spot. A real bad gouge must be filled up. Plastic Wood is very good for this purpose if properly handled. All varnish or oil must be scratched out from the gouged spot, exposing the bare wood. Take a small lump of plastic wood, which is soft and works like putty, and force it into the hole. Smooth off the surface, letting it extend slightly above the hole, and when dry and hard it may be dressed down even with a fine file and sandpaper.

Plastic wood after drying does not take stains readily, and as it is nearly white in color it should be stained before drying. As soon as it is worked into the hole (it begins to set on the surface very quickly) work in a little raw umber or other coloring—even a drop of common brown paint will do in a pinch. Work this well into the surface, but don't work it into the entire mass, or it may cause it to loosen. After it has dried a day or so it may be smoothed down and oiled, using plenty of alcanet or other coloring in the oil.

Instead of Plastic Wood, a mixture of powdered walnut with glue or cement may be used, and this will have a much better color. Set a block of good hard walnut end grain up in the vise and use a moderately fine bastard cut file to make the powder. Sawdust or coarse filings do not work well. Coat the inside of hole with du Pont cement, then very quickly mix some of the cement with the powdered wood to the consistency of the stiff putty, and force it into the hole. Build it up a little higher than the surrounding surface, as it shrinks in drying. Then file and sandpaper smooth, and oil. This mixture should dry two or three days before being filed off. Le Page's glue may be used instead of du Pont cement, but the latter makes the hardest and best repair. Hot glue does not work well for this purpose.

Sometimes when remodeling the service stock of a military rifle, (our own Springfield for example), the barrel channel in forend will be found much larger than the barrel, not touching it at any point. This is called a "full floating barrel." Rather than making a slipshod job by gluing strips against the sides of barrel channel, measure this channel carefully with dividers, and turn up a piece of wood in the lathe to just fill it snugly. Glue this piece into the

[illegible]

channel, and when dry cut off the projecting upper half with rpasw, and plane down level with edges of stock. Then cut a new channel, same as when inletting a new stock, to fit the barrel snugly at bottom and sides. The cutting of a barrel channel is not the difficult job which many suppose, particularly when the action is already inletted.

Another way which I have never seen but have had described to me as entirely successful is to fill in the square grooves under barrel with strips of wood, then quickly pack Plastic Wood into the barrel channel and press the barrel firmly into place, letting it form its own channel, and leaving it there several days until the Plastic Wood is thoroughly dry. The barrel must be covered with a light coating of grease to prevent sticking. My suggestion would be to use Plastic Wood except at the upper edges, and use the powdered walnut and cement mixture here where the filling will show.

While the Springfield service can be remodeled by piecing out where needed, there is little reason for doing so with the D. C. M. Sporter stock available at five dollars to members of the National Rifle Association.

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CHAPTER 15

RIFLE BARREL DESIGN AND FITTING

WE debated a long time as to whether we would include instructions for boring, reaming, and rifling barrels in this book, and we decided not to for several reasons. These operations are a separate art in themselves, and a very specialized art in these

days. To describe them would require several hundred pages, and such description would be intelligible only to a trained machinist or toolmaker, who alone is competent to undertake such work. While it is possible for a very skilled and ingenious machinist to set up an engine lathe to bore, ream, and rifle a barrel, yet generally speaking, heavy and expensive special machine tools are necessary for this work, and these are far beyond the resources of the small professional or amateur gunsmith, necessitating a large and expensive layout which must be in addition to a general purpose machine shop, the latter being needed for related work and for tooling up for the rifling operations. Even a very modest equipment may easily run to $25,000 or higher. The various boring bits, reamers, and rifling cutters cannot be bought, but must be made, hardened, and ground by the workman himself, who must have the necessary skill. Such skill cannot be taught in any book, but requires years of training in general machine work.

There are a number of large companies as well as small firms in this country who supply professional and amateur gunsmiths with barrels bored and rifled to order to any specification at a reasonable price. It is also often entirely practical to remove barrels from certain rifles, such for example as the surplus military rifles which have been sold in large quantities and at low prices since the World War, and fit these barrels to other receivers and chamber them as desired. In addition barrels for the Springfield rifle can be bought by members of the National Rifle Association through the Director

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of Civilian Marksmanship, and these barrels can be cut off at the breech, be rethreaded, fitted to other rifle actions, and rechambered, or of course they can be fitted to the Springfield breech action by anyone having the necessary headspace gages. We are therefore going to confine ourselves to giving the gunsmith that information which will enable him to draw up proper specifications for his rifle barrels, to fit them to proper breech actions, and if necessary to chamber them for the cartridge desired.

BARREL STEEL: In general the steel used in the manufacture of rifle barrels may be divided into four classes:

1. Black powder barrel steel
2. High power carbon steel, sometimes called "Ordnance Steel."
3. Nickel steel.
4. Stainless or rust proof steel.

Under these general classes each barrel manufacturer has his own specifications as to chemical composition and physical properties under which he buys his steel from the steel mills in the form of long bars. It would do us little or no good to know all these specifications in detail, so instead we will look at the general properties of these four classes of barrel steel.

BLACK POWDER STEEL, the steel generally used before the advent of high power cartridges and jacketed bullets, is generally a rather soft, simple carbon steel. It is easily machined, and works up into a smooth, even, and uniform bore and rifling. Its limitations are that it has not the tensil strength and elasticity for cartridges giving breech pressures over about 25,000 pounds per square inch, that is for high power cartridges, and it often wears out very quickly from friction when bullets jacketed with hard metals are used. For .22 and .25 caliber rim fire rifles to be used with lead bullets exclusively it is probably as satisfactory as any of the other classes of steel, and it is believed that its use should now be restricted to these calibers of rifles.

HIGH POWER CARBON STEEL, or Ordnance steel, is the steel now being used by a majority of the manufacturers of high power rifles, including Springfield Armory, The Remington Arms Company, and the Savage Arms Corporation. It is an exceedingly satisfactory steel for all kinds of rifle barrels, being easily machined, having high tensil strength, excellent wearing qualities, and making very fine barrels. A typical composition of such steel is:

Carbon	0.45 to 0.55
Manganese	1.00 to 1.30
Phosphorus (max.)	.05
Sulphur (max.)	.05

Often it is heat treated to increase its yield point and its ultimate strength, which in Government barrels are about 75,000 and 110,000 pounds per square inch respectively.

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NICKEL STEEL is used for barrels by the Winchester Repeating Arms Company, the Niedner Rifle Corporation, and several small barrel makers. It was also used at Rock Island Arsenal at the time that a portion of the Model 1903 rifles were being made there. Theoretically it is the best steel for high power rifle barrels, and it is used almost exclusively in England for this purpose. It is slightly more difficult to machine than carbon steel, sometimes requiring a slight change in tools used. It has high tensil strength, excellent wearing qualities, slightly more resistance to corrosion than the ordinary carbon steels, and makes most excellent barrels. From an entirely practical point of view it has not been demonstrated that nickel steel is markedly superior to carbon steel for rifle barrels, but most riflemen think it is. Certainly among the older and more used rifle barrels in the writer's gun-room, the nickel steel barrels seem to have worn less, and to be brighter and in better condition than carbon steel barrels of similar service. Much of the popularity of nickel steel for barrels is due to its use by the Winchester Repeating Arms Company, who for thirty-five years have been manufacturing barrels of this steel which have been superb in their workmanship, accuracy, and wearing qualities. The chemical composition of Winchester nickel steel is 3 1/2 per cent. nickel and 0.30 to 0.40 carbon, and it is made by the acid open hearth process.

As this chapter is being written STAINLESS OR RUST-PROOF STEEL, is coming more and more into use for a great many purposes. Whether it will be the barrel steel of the future or not cannot be foretold at present. Some of the earlier forms, such as Poldi "Anticoro" steel and Boehler "Antinit" steel, have been imported from Austria and Germany for some years and used in rifle barrels. The chemical composition of these two steels is not known. The American so called "Stainless" steel, as now being used to a limited extent for rifle barrels, is really not a steel at all, but a high chrome iron. A typical composition of this iron as now being used in rifle barrels is chromium 13 per cent., carbon 0.10 per cent., and copper 1.50 per cent. Certain intricate heat treatment is necessary in order to make it both machineable and rust-proof. None of these steels are absolutely rust-proof—all will rust if given enough exposure, but they are very much more resistant to rust than the other barrel steels. Poldi "Anticoro" steel for example, is so resistant that it takes five to ten times as much application of the bluing solution to blue it (which is a rusting process) as ordinary barrel steels. Stainless steel is still further resistant, cannot be successfully blued, and is generally copper plated outside and then subjected to a treatment which turns the copper black. All of these steels are very difficult to bore, ream, and rifle, requiring tools of a very special steel. This, in addition to the original cost of these steels in the bar, make barrels constructed of them much

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more expensive than ordinary barrels. Owing to the difficulties connected with machining, heat treatment, bluing and fitting of these steels, it is thought that they cannot be utilized profitably in work by the average gunsmith who had better place orders for complete barrels fitted to actions and bolts, and ready chambered by the manufacturers specializing in them.

OUTSIDE DIMENSIONS AND WEIGHTS. Besides being of proper steel, a rifle barrel must have a certain minimum thickness or wall diameter in order to be safe against bulging or bursting, this thickness depending upon the cartridge to be used, that is the breech pressure. Other things being equal, the heavier the barrel the more accurate it will always be. Barrel length also must be considered, and there are many other factors which must be carefully weighed in the final determination of the diameter and length of the barrel of any rifle.

The barrels of our old lever and pump action repeating rifles were made very light in weight and small in diameter in order to reduce the weight of the complete rifle. They were also usually cut with two or three transverse dovetail slots for the attachment of sights and forearm. Such barrels performed fairly well with black powder cartridges, the breech pressures of which did not often exceed 20,000 pounds per square inch, and they will still be satisfactory for such light cartridges as the various .22 calibers in rim fire, and the .25-20 and .32-20 center fires. But such barrels are not satisfactory for modern high power cartridges giving pressures from 36,000 pounds to 50,000 pounds, not because they are not safe enough, but because they are not stiff enough. These thin,

slotted barrels when fired with high power cartridges vibrate with very great amplitude and as each cartridge differs slightly from every other cartridge, one may set up a slightly different vibration from the next, and thus cause a delivery of the bullet from the muzzle at a widely varying point in the vibration. The result is mediocre accuracy.

In the design of modern barrels, in addition to safety and stiffness, we must consider the ultimate weight of the rifle and its balance. In a hunting rifle we desire as light weight as is consistent with accuracy and moderate recoil, and the balance should be only a short distance in front of the trigger so it will handle and move quickly for snap shots and shooting at running game. In a target weapon, on the other hand there should be weight to hold it steady, and this will also minimize movement from little tendencies to flinch or jerk the trigger, or small muscular tremors, which will not disturb it so much. And with the target rifle we prefer that it be a little muzzle heavy so that in the process of holding and aiming it will swing slower towards and away from the bull's-eye.

To reduce weight and give the desired balance, and at the same time minimize vibration, the modern hunting rifle barrel is made

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heavy at the breech end. This large diameter or cylindrical portion (see "A" Figure 107) is carried forward to a point corresponding to the forward shoulder of the chamber. There is then usually a short, sharp taper to a point approximately 2 inches ahead of the chamber, thus insuring heavier metal over that portion of the barrel where the chamber makes the walls thinner and where the peak of the pressure comes. From the forward end of this short taper there is usually one (occasionally two) long, straight taper to the muzzle. Figure 107 shows a hunting rifle barrel of this design intended for a high power cartridge, and the accompanying table gives the approximate dimensions at the various points for the

DIMENSIONS OF HIGH POWER RIFLE BARRELS

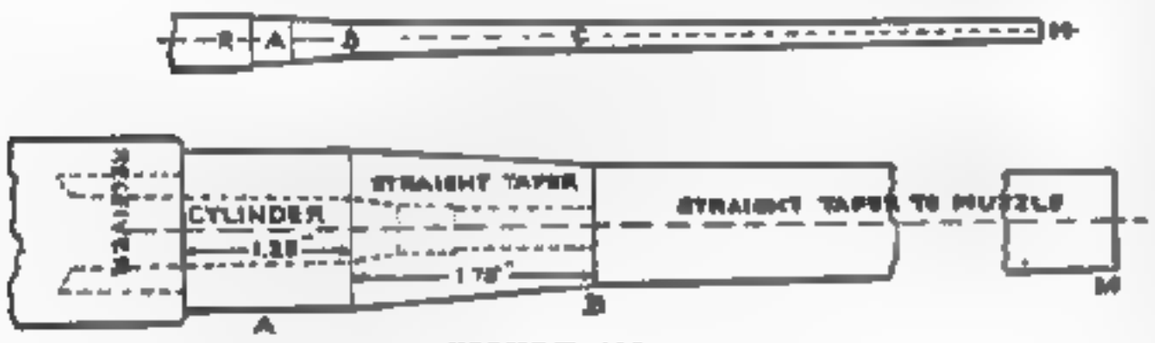

FIGURE 107

No.	Diam. at A	Diam. at B	Diam. at M	Remarks
1	1.00	.78	.60	Minimum weight 26 cal. barrel.
2	1.06	.850	.660	Minimum weight .30 cal. barrel. Accurate .30 cal. barrel.
3	1.14	.956	.647	Springfield .30 cal. service barrel. Diam. at C .71", C being 3.00" from receiver. B-C and C-M being straight tapers. Minimum .35 Magnum barrel.
4	1.14	.956	.647	Springfield .30 and .22 cal. sporting barrels.
5	1.18	1.00	.70	.35 Magnum barrel, minimum .375 and .400 Magnum barrels.
6	1.20	1.05	.76	.375 and .400 Magnum barrels.
7	1.25	....	.875	International Springfield Free Rifle barrel. Taper breech to muzzle.
8	1.05	.....	.90	Winchester Single Shot No. 3 barrel, round, .32-40. Straight taper breech to muzzle.

most common calibers, weights, and kinds of rifles. Generally speaking a barrel of the dimensions of the service Springfield barrel (No. 3 in the table) is the lightest barrel from which really first class accuracy can be obtained with cartridges of power and caliber similar to the .30-06 U. S. Government. Fine results can be had from such cartridges as the .25-35 W.C.F., and .30-30 with slightly lighter barrels. The barrels for .35 and larger cartridges of the Magnum class should be slightly thicker than the service Springfield barrel for the best accuracy and moderate recoil. Particularly

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these hunting rifle barrels should not be suddenly reduced to small diameter an inch or less forward from the receiver. Many foreign hunting rifles have a short radius of concave form cut about a quarter or half inch forward of the receiver, reducing very quickly to a quite small diameter at this point. Such barrels do not, as a rule, give very fine accuracy, for they vibrate excessively, and the slight difference in the load causes very different sight adjustment to be required. There is no objection to making barrels slightly lighter than the above provided their owner understands that he must sacrifice somewhat in accuracy. For example, a .30-06 rifle made with a barrel like the No. 2 in the list will make a fine light rifle for deer and moose in country where these animals are scarcely ever shot at long range, but one must not expect it to perform with satisfactory regularity on mountain sheep at 300 to 400 yards.

Barrels intended for target shooting have much less pronounced tapers, and are heavier. Thus the very heavy "Free Rifle" barrel used in the International Matches (No. 7 in the list) has but one straight taper its entire length from 1.25 inch at the breech to .875 inch at the muzzle. This is about the heaviest barrel that is advisable, as if a heavier barrel be used the muscular effort to hold the rifle of such resulting weight will make for trembling. It is well to have the breech of the barrel where possible, only slightly smaller in diameter than the receiver where the latter joins the barrel, as this gives better appearance than where there is a sudden drop from a large receiver ring to a small barrel. Thus on a Krag rifle, or on the .22 caliber Model 1922 Springfield, or Winchester Model 52, a very excellent diameter for a target barrel is 1.10 inch at the breech, tapering gradually to .75 inch at the muzzle. Such single taper barrels are also better to mount target telescope sights on, where the two bases are screwed to the top of the barrel, than sudden taper barrels of the hunting type.

It will be noted that a majority of the hunting rifle barrels have a diameter of .647-inch at the muzzle. This is for convenience sake to permit of fitting the front sight stud with its encircling barrel band as made for the Springfield rifle, or the many inclined ramp front sight bases which can now be had in more or less finished condition for this size muzzle. If other diameter at muzzle is selected it will usually be necessary for the gunsmith to make by hand the front sight band and stud to fit.

Considering that a Springfield or Mauser breech action is used, and a rather light walnut stock of medium density, with barrel length of 24 inches, a No. 1—.25 caliber barrel or a No. 2—.30 caliber barrel will cause the rifle to weigh approximately 7 to 7 1/4 pounds, No. 3—.30 caliber 7 1/2 to 8 pounds. No. 4—.30 caliber 7 3/ 4 to 8 1/4 pounds, No. 5—.35 caliber 8 3/ 4 to 9 1/4 pounds, and No. 6—.375 caliber 9 to 9 1/2 pounds. Barrel No. 3 differs from barrel No. 4 in that the former has three tapers instead of

two, and is slightly smaller than the latter at a point 9 inches forward from the breech, and hence slightly lighter. A No. 7 "Free Rifle" barrel 28 inches long, on Springfield action with rather heavy stock and heavy International butt-plate will cause the rifle to weigh from 12 1/2 to 14 pounds, depending upon stock, fittings, etc. A Winchester single shot rifle with the Winchester No. 3, 30 inch barrel (No. 8 on list) .32-40 caliber, pistol grip stock, shotgun butt, weighed about 10 pounds. In giving the weight of rifles the weight with iron sights, unloaded, and without gunsling, is usually that given unless otherwise specified.

So far we have not considered BARREL LENGTH at all. Twenty-four inches from receiver to muzzle is perhaps the best average length for high power hunting rifles, except that those of .375 caliber and over had better be regarded as standard at 26 inches. The longer the barrel the higher the muzzle velocity that a given cartridge will develop. With the Springfield cartridge 1 inch in barrel length is equivalent to approximately 25 f.s. in velocity. With the Krag using the older W.A. powder which burns more completely in short barrel length, the difference between a 30 inch barrel and one of 22 inches is only 60 f.s. in muzzle velocity. As the barrel is shortened muzzle blast, flash, and report become greater, and these become very objectional with high power rifles when the barrel is made shorter than 20 inches, which should be regarded as the minimum length for rifles of high power, particularly .30 caliber. Eighteen inches should be the minimum length for .25 caliber barrels, and 22 inches for .375 caliber barrels.

It is not true that the longer the barrel the better the accuracy. The most accurate length for .30 caliber barrels is between 24 and 28 inches, but we cannot say that a 28 inch barrel is any more accurate than one of 24 inches. In fact the longer a barrel the greater

the chance that there may be a tight or loose place in the bore which may affect accuracy, and it is usually best to choose a length of barrel that the factory is accustomed to making on the theory that the workmen will do better work on something that they are thoroughly accustomed to doing day after day than on an unaccustomed special order. Of course if iron sights are used the longer sight radius of the longer barrel minimizes errors of aim. Also some men can hold and swing steadier when firing offhand with a long barrel than they can with a short one. This is why most International Match rifles are made with barrels 28 and 30 inches long. Rifle barrels are usually shortened below 24 inches to make them lighter, or handier on horseback, or because of fancied easier handling particularly in thick brush. One inch of barrel length at the muzzle of a .30 caliber Springfield barrel of service type weighs about 550 grains, or a little over an ounce. To find the weight of a round bar of steel; square the diameter in inches and decimals of

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an inch, and multiply by .2225, and the result will be the weight in pounds of a section 1 inch long. To find the weight of a rifle barrel, or a section of such barrel, first find the weight of a bar of the outside diameter of the barrel, and subtract from it the weight of a bar of the diameter of the bore.

A barrel for a cartridge like the .25-20 can of course be made very much lighter than one for a high power cartridge, and still give excellent results. The barrel on the .25-20 Winchester Model 53 rifle measures .85 inch at breech and .57 inch at muzzle, and is perhaps the minimum barrel that will give fine accuracy in this caliber.

Barrels for the .22 caliber rim fire cartridges can probably be made as light as .60 inch at breech and .40 inch at muzzle if of good steel. Such a barrel 10 inches long fired from machine rest might group as closely as an inch at 25 yards with suitable .22 Long Rifle ammunition. The .22 Long Rifle cartridge seems to give its maximum muzzle velocity in a barrel somewhere between 18 and 22 inches long. It is doubtful if any increase in accuracy (human element eliminated) results from increasing the length over 24 inches or the diameter over that given for the Springfield sporting type barrel (No. 4 on the list). Both weight and length are given to .22 caliber barrels to give proper appearance and balance to rifles, and to maintain a weight and swing that will enable the shooter to hold the rifle steady. Thus the Winchester Model 52 rifle has a quite heavy 28 inch barrel, and the expert shot finds it very convenient from the standpoint of hard and steady holding in all positions. But the same rifle could probably be fitted with a light 18 inch barrel and from a machine rest this light, short barrel might give quite as good average groups as the longer and heavier standard barrel.

TURNING DOWN BARRELS: Rifle barrels should be turned to the desired weight and shape in the process of manufacture, and not after they have been bored, reamed, and rifled. Turning a completed barrel down to reduce its diameters and thus lighten it almost invariably results in releasing strains in the steel to such an extent that the barrel bends considerably. We have seen .30 caliber heavy barrels that were turned down to lighten them bend so much that one could not see through the bore when viewing it from breech or muzzle. Military rifles are frequently remodeled into sporting weapons, and when the military rear sight fixed bases are removed from these barrels there will be a rough, ugly, uneven portion of the barrel exposed Such a barrel may be placed in a lathe and this rough place turned smooth, and the barrel polished for bluing and no bending will result if the work is done carefully.

First you make a plug for the muzzle to hold it in the lathe. This plug is shown in Figure 108. It must be made of hardened steel and ground on centers. If made of soft steel it is liable to cause wear and to freeze in the bore. The long shank which goes into the bore must be a push fit on the top of the lands. The center hole

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must be located and drilled with a small drill, and then countersunk with a 60 degree countersink as in all lathe work. Place the muzzle plug in the muzzle of barrel and fit to dead center of lathe. Put the breech end of barrel in chuck or live center, attach a lathe dog to barrel, and tighten up on face plate with dog and raw hide belt lacing. Then when you have the barrel running truly in the lathe turn a short length on the barrel to true diameter about an inch in front of the rough portion of the barrel. If possible turn only through the bluing or Parkerizing finish. Set the steady rest up here. Then using a second-cut flat file or a mill-file, smooth up the rough portion of the barrel, giving it an even taper and contour with the adjoining portions of the barrel. The file should be moved at right angles to the axis of the barrel, and with light uniform pressure. It is advantageous, although not essential, to give the file a slight rocking movement. Each successive stroke should advance a small fraction of an inch lengthwise of the work until the total length is covered. The file strokes may be slower than in vise work, but holding the file still on the lathe always causes rough and botched work. It is desirable to finish up with a very fine file. When the rough portion has thus been trued up, the entire barrel should be polished to remove the old bluing and to give a mirror-like surface prior to reblung.

If the original barrel had a very rough Parkerized finish it may be desirable to go over the entire barrel lightly with a file to smooth up, leaving the steady rest in place. Then remove the steady rest and lightly file smooth the spot where it bore. Next take medium emery-cloth and move it back and forth by hand lengthwise of the revolving barrel until it is polished and perfectly clean all over. Then repeat with fine and extra fine emery-cloth and crocus cloth each in turn until a perfectly smooth, mirror-like surface is obtained. The barrel is now ready for final polishing as explained in Chapter 18.

It might be remarked here that in purchasing a Springfield rifle for the purpose of remodeling, it is always better to purchase one of the sporting models which has no rear sight fixed base attached, and with a barrel which is already polished and blued from receiver to muzzle, thus making it unnecessary to do all this lathe work, or even to reblue.

STRAIGHTENING BARRELS. When a shooter contemplates turning down a barrel to smaller than its original diameter he should consider carefully the facts and dangers that almost invariably attend such an operation.

In turning down the barrel originally, it was in all probability removed from the lathe and carefully straightened *after each cut.* After rifling, it was again checked for straightness, and straightened if necessary. The pressure of the lathe tool always springs the barrel slightly out of a straight line, so that straightening after each cut is

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necessary to keep the outer surface concentric with the bore. The final straightening leaves the bore approximately straight (very few bores are absolutely straight) and the tension of the metal such that it stays straight under normal conditions.

Now, a cut only a few thousandths of an inch deep, taken from the outer surface of such barrel, may, and usually does release internal stresses in the metal, causing the barrel to spring back to its original crooked or curved state as it was before being straightened.

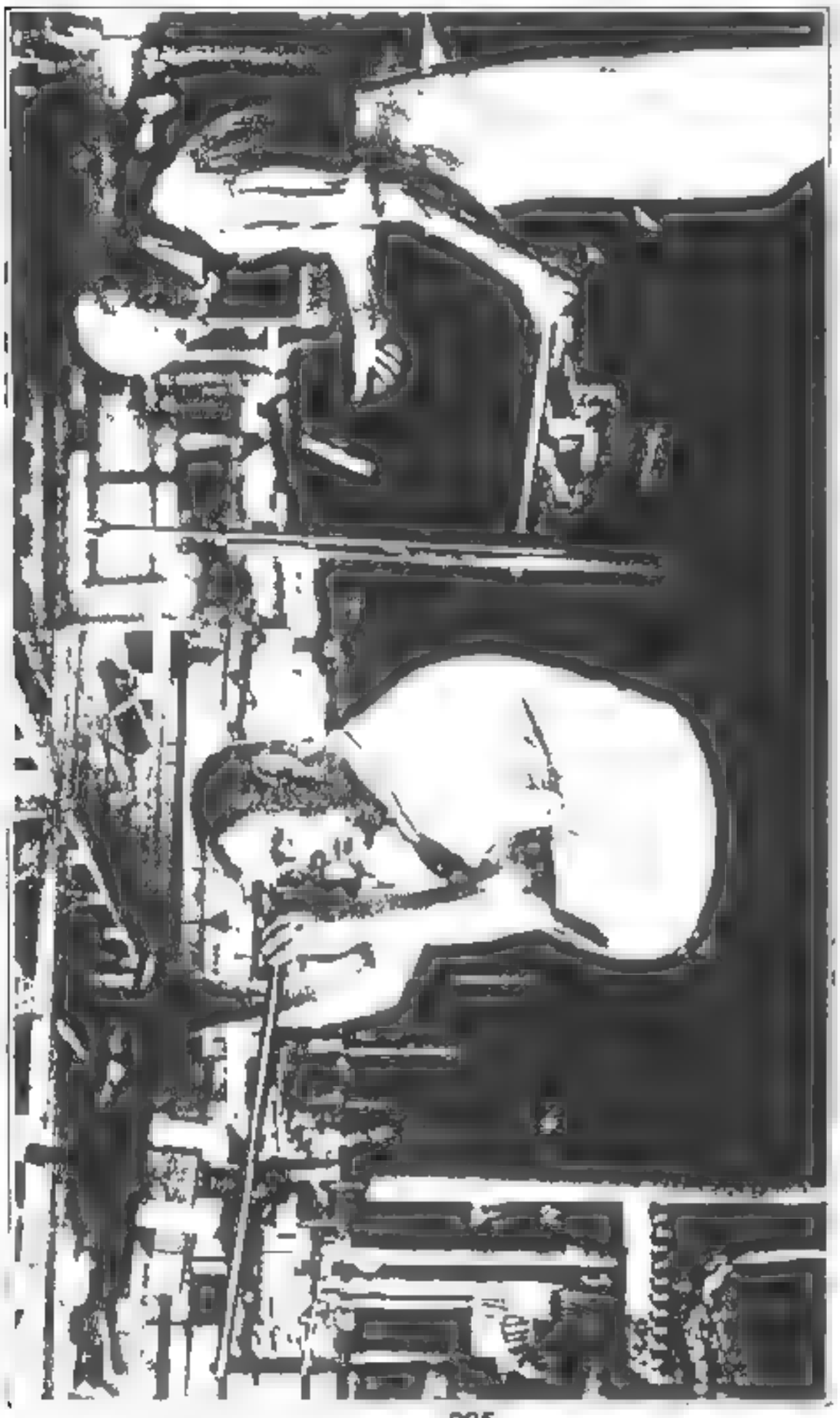
A very common mistake of the amateur is to center his barrel in the lathe, and turn it down to the size wanted, without thought of straightening. The fact is, he probably cannot tell by looking at it whether it is straight or not. He finishes the job and stocks the barrel and action, only to find that it is shooting far—very far—from its previous sight adjustment. Probably it is necessary to shift the sights well off center to bring the group into the black. And—here's the worst of it—that cussed group moves up or down, right or left, stringing its shots all over the paper, as the barrel becomes warm from firing.

How come? The barrel looks straight on the outside—and probably is. But were you to saw it in two at the right point, you would find that the wall was considerably thicker on one side than the other—the difference often being quite plain to the eye, without any measurements. What has happened is that the very first cut taken from the outside sprung the barrel slightly, or else released stresses which permitted it to spring itself. Subsequent cuts, either lighter or heavier, sprung it some more—perhaps causing a compound bend; the light finishing cuts gradually turned the outside true and comparatively straight, while the bore remained crooked. Thus there are places where the wall is thicker on one side of the bore than the other, and this brings about a complicated state of affairs.

The crooked bore causes the barrel to shoot away from its normal sight adjustment; as the barrel becomes heated from firing, the expansion of the thicker wall being greater than that of the thin side, the barrel naturally bends itself in the direction of the thin walled side; and the hotter it gets the more it bends. There is no remedy

for this except straightening of the bore, and turning the barrel down smaller to make it concentric—straightening after each cut—and this is likely to reduce the size entirely too much.

The third result likely to be encountered, will be the increased "whip" of the thinner barrel, making it more susceptible to even the slightest variations of load; such a barrel is permanently erratic in its shooting, and there is nothing to be done for it. The best results that can be obtained from such a tube involve the use of only reduced loads, giving minimum vibration and whip—and the bullets should be selected by weighing and measuring, holding them within limits of 1/4 grain, and of .0005 inch diameter; and powder charges should be weighed, and held to 1/10 grain. Really the best thing



Up at Elion in the Remington factory they can straighten a barrel by either the old or the new method. At the left is shown an operator using the overhead clamp while the party at the right is using a lead hammer and blocks in the old fashioned way.

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to do with such a barrel is to wrap it around the neck of the gentleman who persuaded you to monkey with it.

Straightening barrels is entirely beyond the ability of 99.44 per cent. of all amateurs, and of perhaps 99 per cent. of all professional gunsmiths today. The other 1 per cent. are either barrel makers or barrel straighteners—and they didn't learn it in a day or a week either.

Most factories now use the overhead clamp for straightening barrels. Figure 109 shows this clamp in use. The lower side of this device has two heavy steel "fingers" covered with lead, on which the barrel rests, these fingers being about 3 or 4 inches apart. Above and between them a third finger presses against the barrel from the top, its pressure being regulated by a heavy screw turned by a large hand wheel. The barrel is pointed directly toward a window which has a wire, rod or other clearly visible line in front

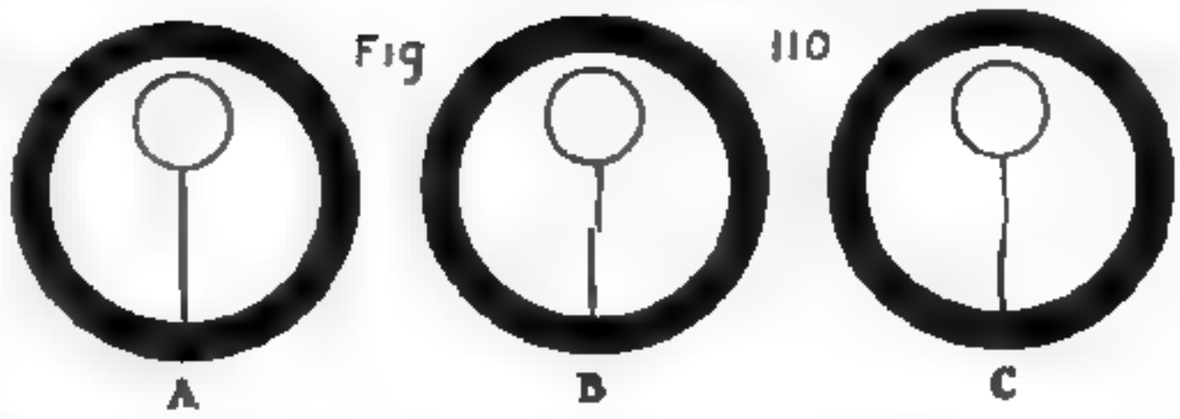

Fig 110

A B C

of it. This throws a distinct shadow along the bottom of the bore. If the shadow's edge appears perfectly straight, as in Figure 110-A, the barrel is straight along that surface if the shadow "breaks," as in Figure 110-B, or shows a curve or bend, as in 110-C, the operator knows there is a crook or curve in the barrel at that point.

The skill of the operator lies in his ability to judge by eye the exact location of the kink or curve, and its direction; and to slide the barrel backward or forward on the lower fingers to exactly the right point, turning the wheel exactly the right amount to exert the required pressure to straighten the bore. By watching the shadow carefully he can tell when it is straight—but here the trouble begins. He must give it enough pressure to bend the barrel slightly in the opposite direction, just sufficiently so that when it springs back, it will spring to a *straight* line. Too little pressure will not remove the bend permanently; and too much will bend a kink in it the opposite way. Taking it by and large, the barrel straightener's job isn't the easiest on earth; yet a few of them become so expert that they can straighten out a bore with great exactness in a minute or so, locating the right place to set the clamp with almost uncanny precision.

The older method of straightening barrels is to rest the barrel

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on two blocks of lead placed close together, striking it with a lead hammer at the point of the bend. I have heard it argued that this method was superior to the more modern clamp, since the sharp hammer blow breaks the fibres of the metal somewhat, preventing the barrel springing back to its original crook as it heats up in firing; while, (so it is claimed) the straightening clamps merely stretch the fibres, making a barrel so straightened more liable to change its point of impact. Just how much merit, if any, there is in these two arguments, I cannot say. I'm not a barrel straightener.

The lead block and hammer method would appear far more difficult for the operator, since he is unable to watch the shadows in the bore while striking the blow; moreover he must learn to regulate the force of the blow with great nicety, which would seem a more difficult accomplishment than learning how much pressure to put on the screw. And since the force required will vary greatly with barrels of varying size and stiffness, the difficulties are further increased. I'll bet my shirt that barrel straightening will not be included in the curriculum of the folks at Scranton for some time to come.

But no matter how some folks are warned away from attempting the impossible, there are those whom such warning merely incites to the attempt; and sure as shootin' some reader is going to insist on trying to straighten a crooked barrel—and just as surely, a few of them are going to be lucky and actually get out the kinks. The well known fact that heaven protects drunks and damphools still holds.

So if you attempt the job, get a bar of lead or soft babbitt about 3/4 inch diameter and cut three pieces each about 5 inches long. Bend these near the center at a right angle, so they will hang on the jaws of the largest vise you can command—one piece at each end of the rear jaw, and one in the center of the front jaw. Turn the vise so it is pointing into a window or door where the light is good, and fasten up a rod or straightedge *horizontally* to cast the shadow. Since the vise exerts horizontal pressure, you will have to watch the side shadow instead of the one on the bottom of bore. Squint through and do your stuff.

RIFLING: Since the introduction of the breech-loader we have seen many systems of rifling—that is many shapes of lands and grooves. Each system has had its advocates, and each has been given very exhaustive tests in comparison with every other system. Thus the Henry system, or its modification, the Pope system, seemed to prove a very distinct advantage for muzzle loading rifles using

conical grooved bullets. The Metford system of rounded lands and grooves was very successful with breech loading, lead bullet, black powder rifles. The Lancaster oval bore system has had many admirers because of ease of cleaning and theoretical long life, but in actual practice has not always given the accuracy desired. The
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Righy system of flat sharp cornered lands, with corners of grooves slightly rounded, appears right in theory for modern high power ammunition with jacketed bullets, but in practice has not shown any marked improvement over the system now in almost universal use in the United States. This system, the Enfield, with an even number of lands and grooves, is used in practically all American rifles, and in most modern foreign rifles. It is used because it gives results which equal those of any other system, and because it is cheaper and easier to rifle a barrel on this system than on others. The lands and grooves are square and have sharp corners. The English gunmakers usually give their barrels an uneven number of lands and grooves, so that a groove is diameterically opposed to a land. In the United States, and on the continent of Europe, however, an even number of grooves and lands are usually used. The number of grooves varies greatly, as well as the width of lands and grooves.

Generally speaking, it may be said that the grooves should be at least as wide as the lands, and that they had better be twice as wide. Four grooves are plenty for rifles of from .22 to .30 caliber. Above .30 caliber it is perhaps best to employ six grooves. There is no real advantage in employing a greater number of grooves than this, but neither is there any great disadvantage in using slightly more. The fewer the number of grooves employed, the cheaper it is to rifle a barrel, and probably the only reason why a larger number of grooves are employed than above is because manufacturers started to use the greater number because of some fancied advantage, and have continued to use that number because they have gotten good results and because they do not care to change their present standards on account of expense. Generally speaking it may be said that the system of rifling employed by all American rifle makers in their barrels is good, and no real or marked advantage will accrue from any change. This refers to the number, width, and shape of the lands and grooves only.

The depth of grooves varies according to the caliber. Long experience has shown that in .22 caliber rim fire, grooves should be .0025-inch deep; in .25 caliber, .0035, for both lead and jacketed bullets. In .30 caliber and larger for jacketed bullets they should be .004-inch deep. Rifles of .32 caliber and larger intended only for lead bullets do well with slightly shallower rifling—about .0035-inch. Large bore magnum rifles using jacketed bullets may often use grooves .005-inch deep, but for .30 caliber .005-inch is usually considered a little too deep.

The diameter of the finish reamed bore before it is rifled is called the "bore" or "land" diameter. The diameter to the bottom of the grooves is called the "groove diameter," and of course it exceeds the land diameter by twice the depth of the rifling.

BULLET FIT: The groove diameter of a barrel has considerable influence on accuracy and barrel life, and this must be understood by the gunsmith who would concern himself with design and specifications for rifle barrels. Groove diameter must always be considered in connection with the diameters of the bullets that are to be used in the rifles. The diameters of the bullets are usually fixed by the ammunition manufacturer, but different manufacturers may use bullets of slightly different diameters for a given caliber of cartridge, so it is best to find out what the average diameter of all bullets likely to be used is, and use that figure in the selection of the groove diameter for the barrel. Rifle barrels can often be had with slight variations in groove diameter, thus allowing the gunsmith a certain latitude in fit between bullet and barrel.

Of course where barrels and bullets are made in quantities by machinery certain tolerances of allowances from the standard diameters are absolutely necessary, for no company can afford to discard its tools as soon as they show any wear. Thus a manufacturer, starting with new tools, will cut his barrels to a certain diameter. As the tools wear or have to be sharpened, the diameter changes slightly, and finally the tools are discarded when they are producing barrels to the limit of the tolerance. The same holds true of bullets, the dies for making which are ground to the minimum diameter, and are discarded when they are producing bullets of the maximum allowable diameter. Most manufacturers have found it best, from the standpoint of economy and excellence of product, to maintain a maximum of variation between maximum and minimum groove diameters of barrels and diameters of bullets about as follows:

	Commercial production	For Match rifles
Groove diameter of barrels:		
.22 caliber	.001"	.0005"
.30 caliber and larger	.003"	.001"
Bullet diameters:		
Lead bullets	.002"	.001"
Jacketed bullets	.001"	.0005"

Thus the ordinary run of inexpensive .22 caliber repeating rifles may have groove diameters running from .222-inch to .223-inch, but the allowable tolerance for the more expensive small bore match rifles made by the same firm may run only from .2225-inch minimum to .223-inch maximum. Likewise another firm may have a tolerance for the groove diameters of its ordinary .30 caliber sporting rifles of from .308-inch to .310-inch, while on the fine barrels it turns out for long range match shooting they may start making barrels .308-inch groove diameter, and discard any barrels measuring over .3085-inch. Lead bullets for ordinary use may vary in different lots by .002-inch in diameter, but the .22 caliber lead bullets which a cartridge company sends to an important small bore rifle competition will probably not vary more than .0005-inch from what may be regarded as standard. One lot of bullets should not vary this much,
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in fact they will hardly vary at all, as they will probably all come from one die on one day's manufacture, but a lot made one day may vary from a lot made the following week, or from a lot made on another press by the amounts given above. It is the constant endeavor of the manufacturer to maintain as good a fit as possible between barrels and bullets. In this he is handicapped by the necessity for making a profit on his goods. He must consider speed of production, wear of tools, and skill of workmen, etc.

SPECIAL BARRELS: Where the gunsmith demands a barrel of exact groove diameter he can sometimes get it if he has a large number of barrels to select from. Suppose for example a large maker's .30 caliber barrels have been found to run in groove diameter from .308-inch to .3095-inch, and the gunsmith wishes a barrel which shall measure between .308-inch and .3085-inch (for nothing is gained in specifying closer than this). By measuring three or four of that maker's barrels he will most probably find one which comes well within his specifications, or the maker himself may even be willing to make the selection for him. But if the gunsmith wishes the same firm to make a barrel for him to a standard dimension, inside or outside, and differing from the standard factory barrel, he must be prepared to pay high for it, for that barrel must be put through the factory as a special job from start to finish, special workmen must set up special machines with special tools for it, and special machine operators must work on it. All this costs like the mischief as compared with the cost of running 1,000 barrels through on machines already set up for standard production, and operated by workmen who have to be skilled only on standardized operations.

Many factories are organized only for standardized quantity production on stock articles, and they may not wish to disturb that steady flow of quantity production, and hence they may very properly establish a policy of refusing special work. In fact most of the large arms companies have established such policies. There may be some special jobs that they will do because they have enough demand for these particular jobs to warrant keeping the special tools needed to do the jobs. For example, at the present writing one of the large companies are making a specialty of furnishing and fitting heavy and selected match barrels to two makes of .22 caliber small bore rifles and .30 caliber bolt action rifles because there is more or less of a steady demand among target shooters for such barrels, and because such barrels used in important rifle matches have a certain amount of advertising value. But if the gunsmith were to approach this same firm with a request to fit a special .38-55 barrel to a Ballard action he would probably meet with a refusal, for there is so little demand for such work that it does not pay to maintain tools for it. He could, however, get his .38-55 barrel from another firm who makes a specialty of making rifle barrels

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strictly to order and to customer's exact specifications, but he will pay twice as much for such a barrel as he would pay the first firm for a regular quantity production barrel.

It is this inability of the large factories to do special work which has caused the recent large growth in the number of small gunsmiths in this country, and finally in the organization of several fair sized gunmaking firms catering entirely to made to order weapons. This also is largely responsible for the interest being shown in amateur gunsmithing, and hence for the writing of this book. A small gunmaker can make a barrel to exact specifications, for every barrel is a special job. But he must employ very skilled workmen, every man probably has to be a $1.10 an hour machinist or toolmaker instead of a $0.75 an hour machine operator, he must discard his tools and make new ones when they show wear at all, and he must employ a highly paid force of clerks and stenographers to handle the voluminous rifle crank correspondence which such a trade entails in this country.

And by the way, let us remark here that the average rifle crank has no right to burden a small gunsmith with a large volume of correspondence. Time, even time at the typewriter, is extremely valuable to such men, and it probably actually costs the small gunsmith from $2.00 to $3.00 a page to answer letters. The crank should not approach such men until he is satisfied just what he wants, and writes only for prices and deliveries. General questions should be sent to the arms and ammunition editor of one of the sporting magazines, or to the Dope Bag Department of The American Rifleman, and let the little gunsmith put in his skill at his bench where he belongs.

But we digress, and there is still one little matter to speak of before we leave this particular subject. It usually costs more for a shop to rebore a rifle barrel to larger caliber than it does to make an entirely new barrel of that particular caliber. This because it takes the most skilled man in the shop to set up for a reboring job. So remember this, when some firm asks you $25.00 to rebore a barrel.

Now we have still to consider the best relationship between groove diameter and bullet diameter. In .22 calibers the best results are obtained when the bullet diameter is slightly larger than groove diameter. Bullets and barrels vary in diameter, and different makers' products vary slightly in standard, but generally speaking the bullet should be from .0005-inch to .002-inch larger than the groove diameter of the barrel to do good work in .22 caliber rim fire rifles. Actually most barrels run from .222-inch to .2235-inch in groove diameter, and most bullets run from .222-inch to .225-inch in maximum diameter of bearing. Practically the desired fit can always be obtained by trying various makes and lots of ammunition in the particular rifle, and selecting the

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lot which gives the best accuracy. Captain Edward C. Crossman's book "Small Bore Rifle Shooting," contains a vast amount of useful information on .22 caliber barrels, rifling, chambering, bullet fit, and ammunition, and no gunsmith doing any work on .22 caliber rifles can afford to be without it.

In .25 caliber high power rifles groove diameter runs from about .2555-inch to about .2585-inch, usually, however, the vast majority of barrels run from .257-inch to .258-inch. Bullets run from .255-inch to .257-inch. From an ideal standpoint both groove diameter and bullet should be .257-inch. Practically, excellent results can be obtained if the bullets are not more than .001-inch smaller than groove diameter. So the expert gunsmith endeavors to get a barrel measuring from .257-inch to .2575-inch, and to select bullets which measure not less than .2565-inch.

We know more in regard to bullet fit in .30 caliber than in any other size, and in .30 caliber the bullets which are made specially for the .30-06 cartridge run closer to standard diameter, and are better made than any other class of bullets. This is one of the reasons why we get better average accuracy from .30-06 rifles than from any other size. .30-06 bullets run very regularly in diameter from .308-inch to .3085-inch. Such bullets will give splendid accuracy in rifle barrels having groove diameters anywhere from .308-inch to .309-inch, and will give very good accuracy in barrels as large as .310-inch. A very wide belief has developed that for best results a .30 caliber barrel should have a groove diameter of .308-inch, and certainly not larger than .3082-inch. This is not borne out in actual results. There is no difference in accuracy between a .308-inch and a .3087-inch barrel that can possibly be determined as due to diameter alone, and it might take a series of 1,000 rounds from a Mann "V" rest to determine that a .309-inch barrel was less accurate than a .308-inch barrel. The other side of the balance is not true, however. A .3095-inch jacketed bullet will not shoot well in a .308-inch barrel until the barrel gets well heated up from repeated firing, and a .311-inch bullet shoots poorly from a .308 or .309-inch barrel and runs the breech pressure unduly high. These principles of .30 caliber bullet fit apply equally to larger bores using jacketed bullets, certainly to as large calibers as .40.

When lead bullets are used with smokeless powder in calibers larger than .22, another principle of bullet fit applies. Bullets must be cast of a rather hard alloy, and should be larger than groove diameter for the best results. In .25 caliber such lead bullets should be from .0005-inch to .002-inch larger, in .30 caliber from .001-inch to .0035-inch. It does not appear to matter what the size of the bullets are provided that they come within these figures, but of course a given batch of bullets must be uniform in diameter, and also they must be of a size such that when seated in the case, the chamber of the rifle will receive the cartridge without undue crowd-

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ing. Bullets smaller than groove diameter do not give good results with smokeless powder, although they do give fair results with black powder which hits the bullet a blow and expands it to bore size even before it starts out of the case. But in many cases even with black powder, better results will be obtained if the bullets be slightly larger than groove diameter. This matter of bullet fit in all calibers, together with the fullest information on ammunition of all calibers is discussed exhaustively in the book "Handloading Ammunition" by J. R. Mattern, which every gunsmith should have for reference. Professional gunsmiths in particular will find that "Handloading Ammunition" will point out to them a way in which they can make additional money and give better service to their customers by handloading and reloading rifle and pistol ammunition. Every gunsmith should also have a copy of the Ideal Handbook published by the Lyman Gun Sight Corporation, Middlefield, Conn., price 50 cents, which gives much absolutely necessary information regarding reloading, bullets, bullet fit, and reloading tools. The following table from the Ideal Handbook gives the average groove diameter and pitch of rifling of the most common calibers of American rifles:

Caliber and Cartridge	*Make*	*Groove Diameter Inches* — *Min.*	*Groove Diameter Inches* — *Max.*	*Twist of Rifling 1 turn in —inches*
.22 Short, R. F.	All	.223	.2238	20
.22 Long Rifle, R. F.	All	.223	.2238	16 to 17
.22 W. R. F.	Winchester	.2255	.226	14
.22 W. C. F.	Winchester	.224	.2245	16
.22 Baby H. P.	Niedner	.223	.2235	16
.22 Savage H. P.	Savage	.224	.2245	12
6 mm. Lee Navy	Winchester	.243	.244	7½
.25 Stevens R. F.	All	.257	.2575	27
.25-20 S. S. & W. C. F.	Winchester	.257	.2575	14
.25-35 W. C. F.	Winchester	.257	.2575	8
.25-35 Marlin	Marlin	.257	.2575	9
.25 Rem. Auto	Remington	.257	.2575	[illegible]
.25 Niedner, Spg. & Krag.	Niedner	.2565	.2575	13
.250-3000 Savage	Savage	.257	.258	14
6.5 mm. Mannlicher	Austrian	.263	.264	7½
.256 Newton	Newton	.264	.265	[illegible]
.270 W. C. F.	Winchester	.273	.2735	[illegible]
.28-30 Stevens	Stevens	.285	.286	[illegible]
7 mm. Mauser	German	.2854	.2874	8.66
7 mm. Mauser	American	.2845	.2855	10
.280 Ross	Ross	.285	.290	8.66
.30-30 W. C. F.	Winchester	.302	.3085	[illegible]
.30-30 Rem. Auto	Remington	.302	.3085	[illegible]
.30 Krag	U. S. Govt	.305	.310	[illegible]
.30-06 Springfield	U. S. Govt	.302	.309	[illegible]
.300 Savage	Savage	.302	.309	[illegible]
.30 Magnum	Griffin	.3082	.3085	14
.32 Short and Long R. F.	All	.313	.316	20 to 24
.32-20 W. C. F.	Winchester	.311	.3115	20
.32 Ideal	Stevens	.323	.324	12
.32-40 W., B. & M.	Winchester	.320	.3205	16
.32 Win. Special	Winchester	.320	.3205	16
.32 Rem. Auto	Remington	.319	.3195	14
8 mm. Mauser	German	.313	.326	9 to 16
.303 British	English	.312	.314	10
.303 Savage	Savage	.30[illegible]	.309	10
.32 Win. Self-Loading	Winchester	.31[illegible]	.352	10
.32 W. C. F.	Winchester	.338	.3385	[illegible]
.35 Win. Self-Loading	Winchester	.351	.352	[illegible]
.351 Win. Self-Loading	Winchester	.321	.322	[illegible]
.35 Rem. Auto	Remington	.356	.3565	16
.35 W. C. F.	Winchester	.353	.3585	[illegible]
.35 Whelen	Griffin	.357	.3575	[illegible]
.35 Newton	Newton	.359	.359	[illegible]
.35 Magnum	Griffin	.357	.3575	[illegible]
.375 Magnum	Hoffman	.375	.376	14

.38 Short, Long and Extra Long, C. L.	All	.358	.359	16
.38-40 W. C. F.	Winchester	.400	.4005	10
.38-40 W. C. F.	Remington	.400	.4005	10
.38-55 W., B. & M.	Winchester	.373	.3795	18
.38-56 W. C. F.	Winchester	.373	.3795	10
.38-70-255 W. C. F.	Winchester	.370	.3795	14
.38-72-275 W. C. F.	Winchester	.370	.3795	12
38-90 W. C. F.	Winchester	.370	.3795	16
40-50 Sharps Straight	Winchester	.403	.405	12
40-70 S. S. and Ballard	Winchester	.403	.405	20
.40-70-330 Win.	Winchester	.403	.405	20
40-72-330 Win.	Winchester	.404	.407	22
40-82-260 Win.	Winchester	.402	.405	12
40-90 Sharps Straight	Winchester	.402	.405	16
.40-110 Win.	Winchester	.402	.405	22
40 60 Win.	Winchester	.403	.405	40
400 Whalen	Griffin	.4105	.4115	14
.401 Win., S. L.	Winchester	407	408	14
404 Magnum	Hoffman	.412	.414	14
405 Winchester	Winchester	.413	.4135	14
.43 Spanish	Winchester	.439	.440	10
.44 40 W. C. F.	Winchester	.4335	.429	26
44 Henry R. F.	Winchester	.4335	.4195	26
45-60 W. C. F.	Winchester	.456	.458	20
.45-70 Winchester	Winchester	458	.458	20
.45-70 U. S. Govt.	U. S. Govt.	.457	.458	22
45-75 W. C. F.	Winchester	.456	.458	20
45-90 W. C. F.	Winchester	.456	.458	22
45-125 W. C. F.	Winchester	.456	.458	26
45 Sharps, 3¼	Sharps	.462	.469	18
.50 Sharps	Sharps	.509		
50-95 Winchester	Winchester	.512		26
50-1110-460 Win.	Winchester	.512		54
50-70 Govt.	U. S. Govt.	.515		24 & 12
505 Magnum	Hoffman	.5045	.5055	16
52 Govt. M. L.	U. S. Govt.	.509		52

It may be said that this table shows dimensions which are the results of many years of experience. The dimensions are those which best fit existing bullets, and they should be departed from only after considerable experience and careful thought and study.

Chapter 16

CHAMBERING AND BARREL WORK

THE MEASURING OF BORES: The Ordnance Department takes the measurements of the bores of Springfield and Krag rifles with an instrument called a "Star Gauge." This is a long steel rod, bored out to contain another rod inside it. One end of the smaller rod contains studded projections which fit tightly into the grooves, expanding to fit the bottom of the grooves when the smaller rod is pushed into the larger rod, and a scale on the breech end of the rod gives the groove and land diameters. The combined rod is inserted the desired distance into the bore, the inner rod pushed up until the projections come up tight against grooves or lands, and the diameter read off the scale. Thus the groove and bore diameter can be recorded for every inch of the bore from chamber to muzzle, and any tight or loose places can be determined.

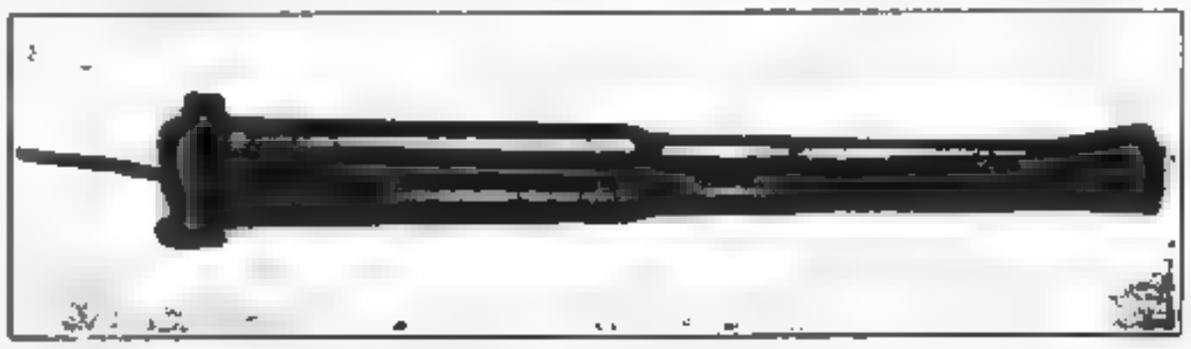
A star gauged barrel is simply one which has thus been measured and found to come within certain prescribed limits. Usually a barrel is not sent out from an Ordnance Department arsenal unless the groove diameter comes within the figures .308 to .3085-inch, and unless it is practically free from tight or loose places. Star gauges are very expensive, and are not available except at Government arsenals.

But there is another way to measure the bore of a rifle barrel which is about as good. This is by driving a bullet through the bore, and then measuring the bullet with a micrometer caliper. Select a bullet of pure lead which is several thousandths of an inch larger than the expected groove diameter of the barrel you wish to measure. It should have a rather short bearing surface. For example, if you wish to measure a .30 caliber barrel about the best bullet to use is the regular factory lead bullet for the .32 W. C. F. cartridge, which is short, of pure lead, and measures .311-inch. If you have no bullets correct in size, turn some up on a lathe of

pure lead. Clean the barrel thoroughly and lubricate it very lightly with a thin oil like "3 in 1." Have a stiff, steel rod about ten inches longer than the bore, and almost the diameter of the bore, with a square, blunt tip. Slightly lubricate the bullet, drop it point first into the chamber, and with the rod shove it about an inch into the rifling. It may be necessary to hit the rear end of the rod a few light blows with a hammer to get the bullet started into the rifling. Insert the rod into the muzzle, and very carefully press the bullet out again at the breech. Slight tapping with the rod on the point of the bullet may be necessary. Catch it as it comes out so that it does not fall and deform itself, and measure it with a micrometer caliper. Measure across portions which fitted into bottom of grooves. This will give you the groove diameter of the barrel at the breech. In a similar manner push a bullet into the bore and with the rod shove or drive it straight through the bore to within about an inch of the muzzle. Sometimes the bullet can be shoved straight through, but often it will require light taps on the rear end of the rod with a hammer to gradually drive it through, and if these taps be made light and uniform, the resistance of the rod to the hammer will give a fair indication as to whether there are any tight or loose places in the bore. Now with the bullet near the muzzle, hold the fingers at the muzzle so as to catch the bullet as it comes out, and holding the rod in the other hand, tap light blows on the base of the bullet, gradually driving the bullet out at the muzzle. Catch it with the fingers and measure it, thus obtaining the groove diameter at the muzzle. In measuring these bullets, always measure the greatest diameter, from the raised portion which has upset into the groove on one side, to similar portion on the other side. To obtain bore diameter, with a very sharp knife carefully cut away the raised groove portions on either side so that the micrometer will fit into and measure those portions which bore on the tops of the lands

To determine the smoothness of bore, and to detect and locate any possible tight or loose places in the bore, place the barrel in a heavy vise, using brass jaw covers so as not to mar it. Force a lead bullet into the breech as before. Have a good big cross-piece handle on the rod or wrap it heavily with a piece of cloth. Get the body weight behind the rod, and force the bullet through the bore with a steady motion, as slowly as you can move without letting the bullet stop for an instant. It should take two or three seconds for the bullet to pass through a 30 inch barrel. If it goes through with an even and gradual speed and pressure it is fairly uniform, but if there are tight or loose places the difference in pressure and speed will show these up. A little knack is necessary and one should practice it three or four times, and should also repeat the test a few times to be sure of his findings. The best barrels are those which have no tight or loose places, but have even diameters from breech to muzzle, although most riflemen have the opinion that a rifle to shoot lead bullets exclusively will do better work if it gets just a little bit tighter towards the muzzle, being gradually tapered.

MEASURING CHAMBERS: To measure the chamber of a rifle it is necessary to make a sulphur cast. The chamber, and about one inch of the rifling forward from it, should be thoroughly cleaned and then covered with a very thin film of light, clean oil. Take a cork the size of the bore of the rifle and drill a small hole through its exact center. In this hole place a piece of straight wire, about .0625-inch in diameter. Press the cork into the chamber and up about half an inch into the rifling, so that the wire extends through



A FINISHED SULPHUR CHAMBER CAST

the cork and back to a point several inches in rear of the breech. The wire functions as a handle for the cast as the cast is very brittle. The mixture for the cast is made of the following materials:

Sulphur	8 ounces
Powdered lamp black	4 grains
Gum camphor dissolved in alcohol	1 drops

Heat very slowly and stir continually. When the mixture arrives at a thin pouring consistency, pour it into the chamber quickly, and allow to cool thoroughly before removing. To remove, place a rod in the muzzle and shove lightly on the cork, letting the cast come out slowly, and handling it very gingerly as it is quite brittle. This cast can now be measured with a micrometer and scale, and will give the dimensions of the chamber as well as its shape. The

mixture is almost shrink proof, but it is well to allow .0005-inch for shrinkage if measured at once, or .001-inch if measured a day after cast. It is important that the mixture be heated slowly, otherwise it becomes too thick to pour.

TWIST OF RIFLING: The table on the previous page in Chapter 15 shows the twists of rifling which have proved best for various calibers and cartridges as a result of years of experience. The lower the muzzle velocity, the longer the bullet, the poorer the quality of the bullet, and the longer the range at which accurate results are desired, the quicker the twist of rifling must be to correctly spin the bullet so that it will keep point on and fly accurately.

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For example: the standard twist of the .25-20 rifle is one turn in 14 inches. In black powder days that twist often failed to keep an 86 grain bullet from keyholing slightly because the velocity that could be given with a full charge of black powder was too low for the combination of twist and length of bullet. Seventy-seven grain bullets gave much better accuracy with black powder. Today smokeless powder gives higher velocity, and a 14 inch twist is ample for an 86 grain bullet in .25-20 caliber. A 14 inch twist will fail to spin a 117 grain .25 caliber bullet at M. V. 2,000 f. s., but will spin it very nicely and keep it point on up to 200 yards at least if the velocity be increased to 2,500 f. s., but if accuracy is desired at very long range the twist had better be one turn in ten inches for a .25 caliber barrel to use 117 grain bullets.

A standard twist of one turn in 10 inches has been established for .30 caliber rifles. A 14 inch twist is sufficient to spin a perfect 220 grain .30 cal. bullet to 1,000 yards, but such a twist may permit a poor 220 grain bullet to keyhole at 600 yards, or a perfect 220 grain bullet to keyhole at 1,500 yards. The 10 inch twist is dictated by military necessity for accuracy at extremely long range with war time ammunition. A 14 inch twist might be ample for a hunting rifle and excellent ammunition, because accuracy over 400 yards is not demanded. Slow twist, if permissible, is an advantage as it makes for less friction, hence longer barrel life, and greater ease in cleaning.

THREADING BARRELS: The gunsmith may find it desirable or necessary to thread new rifle barrels to fit them to certain receivers. Or he may desire to cut the thread off of an old barrel, and rethread it for another receiver, which of course involves rechambering. Or again it may occasionally be necessary to turn the thread off of a barrel, shrink or solder on a sleeve, and cut a new receiver thread on the sleeve. All of these jobs he can readily do provided that he is a trained machinist and familiar with the cutting of screw threads on the engine lathe. If he is not accustomed to this work he must either serve an apprenticeship at it, or he must farm this work out to some competent machinist, or preferably to a barrel making firm.

The threading of a barrel is inseparably connected with chambering and headspacing, and all who attempt to thread barrels must have a complete understanding of these subjects which are explained later. Rifle makers use many different styles of thread and pitch for their receivers and barrels. There is no standard, and we find on various makes of rifles, the "V," Whitworth, U. S. Standard, National, and Square forms of threads. The thread of the barrel must be cut so that there will be a small tolerance between threads of receiver and barrel in order that the index lines will meet when the barrel is screwed entirely home with a wrench.

FITTING BARRELS TO RECEIVER: The barrel should screw fairly easily to within about 1/4-turn of meeting of index lines, and should then require a heavy wrench to screw entirely home. The "index lines" are the two short, almost invisible lines, one cut in receiver, and one in barrel, which meet exactly when the barrel is screwed entirely home into the receiver. The assurance of correct headspace and security of barrel in receiver are the most important reasons for seeing that barrel is screwed exactly to index lines, but also if front and rear sight bases have previously been mounted on the barrel, then these should stand truly vertical when the index lines meet.

If it is impossible to get the index lines to meet when the barrel is screwed up forcibly with a long wrench, then instead of easing up on the threads to give them more tolerance than is allowed in good machine practice, the face of the shoulder on the barrel should be lightly squared off until they do meet. Some barrel makers lay great stress on the fitting of this shoulder to the end of the receiver ring, and employ the "spotting" method to secure perfect contact. One celebrated barrel maker maintains that best accuracy, particularly in .22 caliber match rifles, is obtained when the entire surface of the barrel shoulder is in perfect contact with the end of the receiver, with equal pressure at all points. To "spot in" a barrel, the end of the receiver which bears against it is very lightly coated with Prussian blue, and the barrel screwed in fairly tight; then remove it and note the spots of contact. Dress them off carefully with very fine files—a 3-inch die-sinker's needle file will usually serve; or some of the various die-sinker's rifflers as made by the American Swiss File Company. Continue the spotting and test-fitting until the contact is perfect when barrel lacks about 1/16 inch of being screwed up; then give the wrench the final twist which sets it all the way.

Figure 111A shows a good type of wrench to use in screwing barrels into and out of receivers. It is made by welding or brazing a piece of tool steel to the upper jaw of a large monkey wrench, with handle from 18 to 24 inches long. The notch in this false jaw is cut at an angle of 90 degrees, giving it two-point contact on the round, upper portion of front end of receiver. The flat lower jaw bears against the flat portion found on the under side of most bolt action receivers, and the wrench should be screwed up rather tightly. It is advisable to drill four to six 1/8-inch holes in the set-screw of the wrench so that it may be tightened with a short length of drill rod. The surface of both jaws of the wrench should be polished off smooth to avoid marring the receiver, and the jaws may be modified as desired to obtain purchase on receivers of various types. Most lever action and single shot receivers have two flat surfaces on either side on which a standard long monkey wrench without modification of jaws other than to polish them, will take hold.

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Never hold the receiver in a vise and screw out the barrel when it can be avoided. Rather hold the barrel in the vise and turn the receiver with the wrench. A good inexpensive method of holding the barrel in the vise so that it will not be marred is as follows: Take a piece of Shelby tubing, 4 inches long, with inside diameter slightly smaller than barrel near the breech, and walls about 1/4 inch thick. Taper ream this to be the same taper and diameters as the barrel it is to be used on, then split one side with hack-saw or milling cutter. Slip it over the barrel snugly, then grip it in a pair of pipe jaws in a large vise, setting the vise up as tightly as possible, and use the wrench on the receiver as above. If this split tubing is used on a straight taper barrel it may be made to fit clear back to the breech. However, on a barrel with two or more tapers it would be both difficult and expensive to ream the sleeve to fit; so in such a case fit it far enough forward to get a single straight taper.

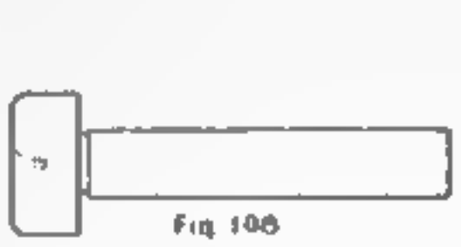

Fig 108

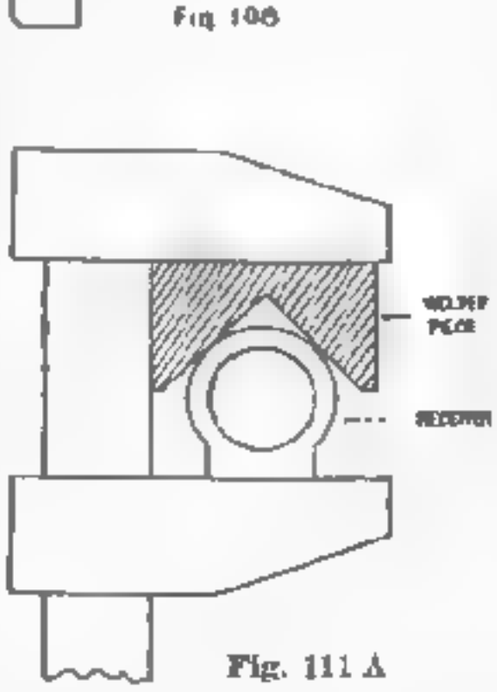

Fig. 111 A

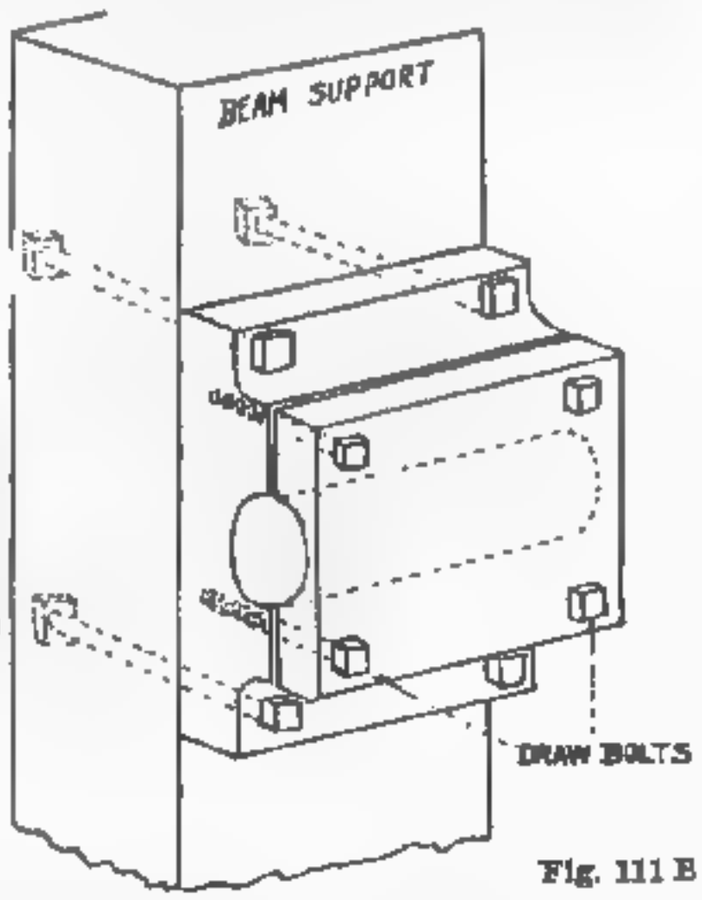

Fig. 111 B

When seating new barrels which screw in very tightly, particularly if one has to set up many barrels of exactly the same type or outside dimensions, a pair of blocks as shown in Figure 111B will pay for themselves, although rather expensive to make. Cast-iron is probably as good material as any for this purpose, and it is easily machined. A heavy block is first drilled and then reamed to fit the barrels, and then split on both sides with milling cutter.

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Or the two blocks may be made separately and the barrel groove profiled. Holes for 1/2 inch draw-bolts are drilled, and the device bolted firmly to some solid upright support, such as a roof supporting beam in the shop. With a clamp of this kind, and the barrel grooves lapped out and polished, barrels already blued may be screwed into receivers without the slightest danger of marring the finish. I have not had much success with wooden blocks hollowed out to fit the barrel, as perfect contact required for a non-slip grip can hardly be obtained in wood. Some gunsmiths use these blocks hollowed out larger than the barrel and lined with heavy leather glued in, and dust the surface of the leather with powdered rosin. This method is all right if it works—sometimes it does.

Most .22 caliber barrels are easily removed, as they are usually not screwed in as tightly as the high power barrels of larger caliber. Octagon barrels are easy—hold them in an ordinary flat jawed vise with sheet brass or copper to protect the barrel.

Be careful in all cases to avoid marring, bending, denting, or springing the receiver. If it is of a shape which cannot be readily gripped in a smooth jawed wrench without damage, better inlet a couple of hardwood blocks to fit its contour, and grip these blocks with the wrench. Sometimes a piece of sheet lead wrapped around it will solve the difficulty. In the May 1, 1923, issue of The American Rifleman, Colonel Stodter offered a method of removing Krag barrels from actions, which is substantially as follows:

"The first problem is to remove the old barrel. Take two pieces of wood about 4 x 6 inches and two inches thick and shape them roughly with saw, chisel and rasp to fit on each side of the receiver."

"Place the receiver with blocks in place in the vise and screw it up tight so as to hold the receiver securely Take a piece of strong rope about one-half inch in diameter and twelve to fifteen feet long, double it in the middle, stick the end of a pick handle or similar piece of strong wood through the loop and wind the doubled rope smoothly and tightly from near the breech toward the muzzle. Wind the rope in the proper direction so that when the lever is rotated around the barrel so as to tighten the rope the twisting force will be exerted in a counter clockwise direction and tend to unscrew the barrel."

"Hold the rope tightly near the muzzle with one hand and twist the lever with the other hand. By getting a shoulder under the lever and lifting up great force can be exerted. If this does not get results, heat the receiver slightly with a blow torch or a candle. This will usually expand it sufficiently to allow the barrel to be unscrewed."

A word of caution. Remove the bolt or breech mechanism before attempting to remove the barrel. Such a warning seems superfluous and unnecessary, and should be, but I have seen a gunsmith of thirty-odd years' experience grunt and twist a barrel out by main strength and awkwardness without even opening the action, breaking off the extractor finally, and cutting a slice out of the breech with it, and then cuss for ten minutes without repeating himself!

CHAMBERING: Chambering of rifle barrels is an operation

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that many gunsmiths may be called upon to do. If they undertake it they should know all about it as it is extremely important that it be done exactly right. On the correct chambering of a rifle barrel depends its safety, its accuracy, and to a great extent its length of life, to say nothing of its ability to handle its cartridges efficiently. Let the gunsmith make a little slip in design, workmanship, or dimensions and the barrel may have no semblance of accuracy, and what is more important, it may maim or kill the man who fires it. Chambering is inseparably connected with the threading of the barrel, and with headspacing, and these three operations must be considered together.

At the time that this is being written there has occurred a case where a very prominent maker of hand made rifles turned out a rifle for an equally prominent rifleman, which had a little excessive headspace. Moreover the gunmaker acquiesced in the rifleman making his own cases for this rifle by necking down existing .30-06 cases in a hand tool. This of course resulted in the cases being not uniform, which is exactly the same as though the rifle had very excessive headspace for some of the cartridges, for if there is anything that takes the greatest skill it is the forming of dies for assuring the exact dimensions of cartridge cases. The result was a most serious accident which crippled the rifleman for life, and he was very lucky not to have been killed.

Every gunsmith who undertakes chambering, or the fitting and threading of barrels should know exactly what he is doing, and why; he should have good mechanical ability, and he should be equipped with the best of tools. These are not operations which an amateur can do right the first time. Nor are they operations which riflemen should trust to any gunsmith. Purchasers of rifles should ascertain that their gunsmith has the necessary skill, or else they should insist that their rifle be chambered, and the receiver and bolt fitted at a factory where there is no doubt whatever that the proper and necessary skill will be used and every precaution taken.

Briefly, chambering consists of reaming out the breech of the barrel with a series of fluted reamers known as chambering reamers, so as to form the enlargement or chamber into which the cartridge fits. The operation is done gradually, each reamer in turn being slightly larger than the preceding one. Before the last, or finishing reamer is used, the barrel is threaded and fitted to the receiver, and finally the finishing reamer is run in to exactly the right depth in conjunction with a set of headspace gages and the breech block that is going to be used in that individual rifle, to be certain that the chamber is cut to exactly the right depth, and thus assure correct headspacing.

If the diameters or length of the chamber be too small the cartridge will not fit, or it will give too high—possibly dangerous—pressures, or the fired cases will be difficult to extract, and in

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addition, unless bullets of a very even and selected diameter be used, it will probably result in an inaccurate barrel. If the diameter of the chamber be too large the barrel may be inaccurate, although we have seen some large chambered rifles shoot with a very fair degree of accuracy; also the life of the barrel will be short due to gas cutting, and the fired cases will expand so much that they cannot be reloaded—they may even split If the chamber be too long, that is too much headspace, the cartridges may misfire, the primers may blow out, the cartridge case may separate a half inch in front of the head leaving the forward portion of the case lodged in the chamber, and even the whole head of the case may blow out, allowing gas to escape to the rear, completely wrecking the breech mechanism, and perhaps seriously injuring the shooter. In many of the measurements of the chamber even a few thousandths of an inch may make all the difference between success and complete failure or disaster.

The first detail we will take up is that of the design of the chamber, that is its dimensions and shape with reference to the cartridge that is to be used. The dimensions and shape of the chamber must be based on the dimensions and shape of the cartridge, and the kind of load that cartridge contains, and must also conform to good ordnance engineering practice. No cartridges are made absolutely uniformly, but are made with maximum and minimum dimensions, the system of inspection at the cartridge factory insuring that no cartridge will be produced larger than the maximum measurements, nor smaller than the minimum measurements. The chamber must be cut to fit and operate safely with either a maximum or a minimum cartridge. To do this it is necessary that it be just large enough to work successfully and safely with the maximum cartridge, but no larger, for if it is larger it will probably be unsafe with the minimum cartridge. This establishes the size and shape of the chamber within very close limits.

Unfortunately most gunsmiths are unable to obtain the dimensions of maximum and minimum cartridges from the cartridge makers, who usually regard their drawings and designs as confidential. Fortunately we can, in most cases, arrive at a very close approximation of the dimensions of the maximum and minimum cartridge from the measurements of a number of standard factory cartridges of the various makes, the mean of the measurements of which may be taken as the average or mean cartridge. These measurements should not be taken from cartridges of only one make, for these may differ from those of some other make slightly, and you want the rifle to be satisfactory with cartridges of all standard makes. Therefore, when starting to design a set of chambering reamers,

one should first obtain at least twenty cartridges of all makes of that caliber, and also sometimes all the varieties loaded with different weight bullets.

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Figure 112 gives the maximum and minimum dimensions of the .30 caliber M1 (.30-06) and the .30 caliber Model 1898 (Krag) cartridges, the measurements being copied from official Ordnance drawings. The mean or average cartridge may be taken as being the mean of these extreme dimensions. Thus if the gunsmith will measure a lot of any other make and size of cartridges, and average these measurements, he arrives at a series of mean measurements for that particular make and caliber of cartridge. Then take half the difference between the maximum and minimum dimensions as shown in Figure 112A or Figure 112B, and add it to these mean dimensions, and you have what may be regarded as the maximum dimension of the particular cartridge you are considering. These, then, are the dimensions which you use for the maximum cartridge in considering the design of your chamber. Several hours can profitably be spent with 100 cartridges (20 of each five makes), a micrometer, vernier ruler, pencil, and paper, in determining measurements, and this work should be checked and rechecked to be sure that there is no error anywhere. Do not shirk it. The result will be a drawing of the maximum cartridge for which the chamber should be cut.

Figures 112A and 112B also show the maximum and minimum chamber dimensions for the .30 caliber M1 (Springfield), and the .30 caliber Model 1898 (Krag) chambers. If the chamber is to be cut for some cartridge other than these, there should be the same tolerance between the maximum cartridge selected and determined, and the finishing chambering reamer as there is between the maximum cartridge and the maximum chamber in these drawings. The finishing reamer should always be made to cut the maximum chamber, for as it is used on barrel after barrel it will become dull, will have to be stoned to sharpen it, which will of course reduce its size, and then it must be discarded when it is cutting the minimum chamber, or else ground down for use as one of the preliminary reamers.

A lot of foolishness has been written about minimum or tight chambers. Many shooters seem to think that tight chambers are very desirable, and that they are more accurate. The truth is that tight chambers are very undesirable. They are fairly accurate only when a bullet of the exactly correct diameter is used, and it is often extremely hard to get such bullets. Chambers cut with the relative dimensions and tolerances shown in the drawings are the most accurate and satisfactory chambers known. Practically every American manufacturer is now designing his chambers for new cartridges with tolerances between maximum cartridge and minimum chamber very closely approximating those shown here, and we cannot too firmly impress upon the gunsmith that he should follow these as a guide.

Very often a customer will write to a gunsmith or a manufac-

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turer, and state that he desires a barrel cut with an extremely tight chamber, or a chamber of some peculiar shape. The gunsmith might very properly refuse to cut such a chamber from the standpoint of safety alone. But he can also plead the cost of making the necessary reamers. Certainly the cost of making the two finishing reamers which will probably be necessary to cut a chamber to some special dimension would be not less than $40.00 in man labor, plus at least the same amount for machine labor, both doubled for overhead. To these we might add the day's labor of the highly trained man spent in figuring out dimensions as previously described. Indeed a complete set of chambering reamers today costs from $200 to $300 to make, and the customer who glibly talks about having a specially chambered rifle, hardly realizes what he is getting into in the way of expense if he really wants to go any further than bothering the gunsmith with many letters about it.

When one starts to chamber a barrel it is probably bored, reamed, and rifled all the way to the breech end. A series of about four to six reamers are used, graduated in size and diameter so that each succeeding one makes a shallow cut, and slowly and gradually enlarges the chamber to the desired size and shape. See Figure 113. The reamers are made by hand, being ground from fluted reamers purchased from gage and tool-making firms. They are usually used by hand, although in large arms factories they are operated for

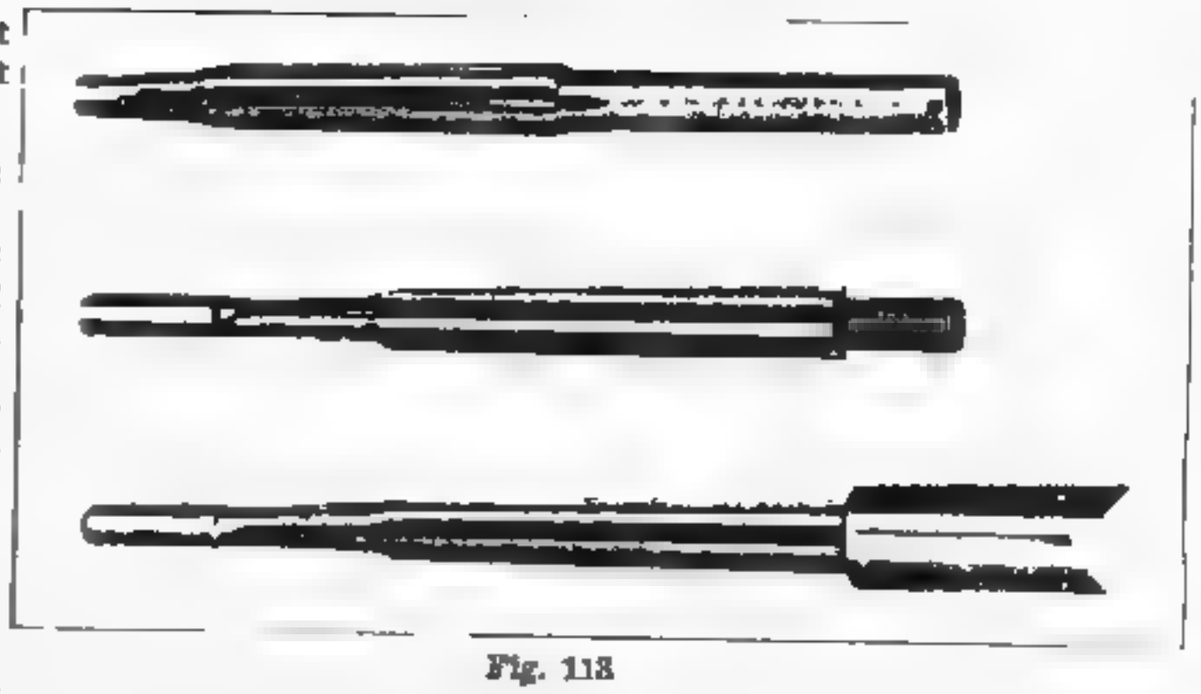

Fig. 113

convenience and speed in a special turret lathe. It is a principle of reaming that a reamer, if operated by hand, and if not forced unduly, will ream out exactly in line with the axis of the original bore. To assist in this, each reamer is provided with a pilot or cylindrical portion in front of the cutting edges, which, riding on the top of the lands, acts as a guide and a centering agent for the

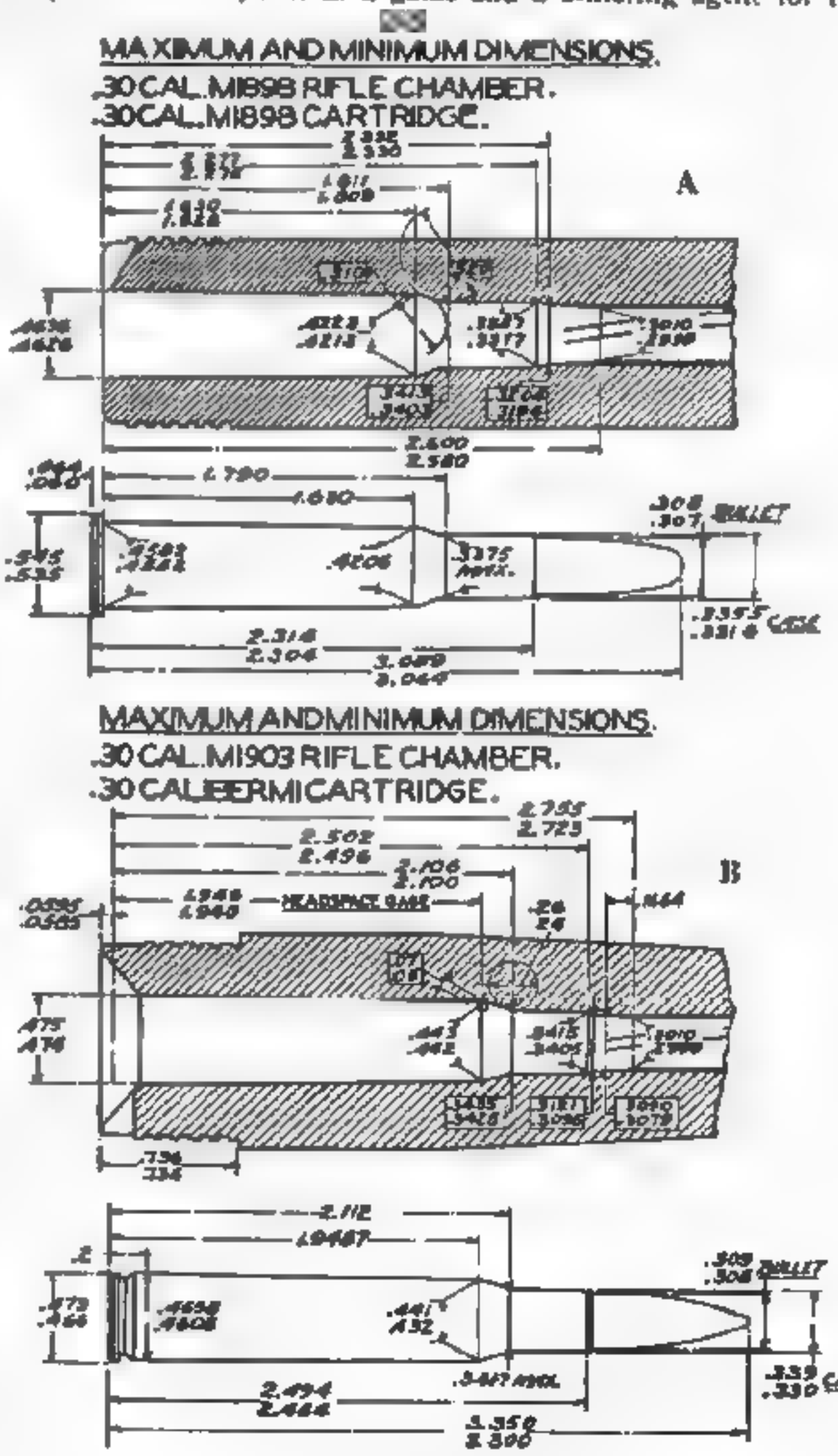

Fig. 112

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front of the reamer. This pilot is ground and polished to be a push fit on the top of the lands. There are also stop guides at the

rear of the reamers to show when each has been run into the chamber deeply enough.

The finishing reamer, that is the final one used, must be ground to very close dimensions, and it is this reamer also which cuts the bullet seat or lead. The bullet seat is that portion of the chamber ahead of the mouth of the case, into which that portion of the bullet projecting out of the brass cartridge case fits. It should be cut so that the ogive of the bullet, that is the curve of the point, will just barely touch the origin of the lands, and the beginning of the lands should be cut on the same curve or slope as the ogive of the bullet. Usually there is a short portion of the chamber ahead of that portion corresponding to the mouth of the case, which is cut cylindrical and smooth by simply reaming out the lands, leaving this portion a true cylinder of groove diameter. This cylindrical portion receives the portion of the bearing or maximum diameter of the bullet which projects outside of the case. Then ahead of this the lands start on a gradual slope.

Generally speaking, the best accuracy is obtained, other details being correct, when the cartridge and bullet are so shaped and assembled that there is a portion of the cylindrical, maximum diameter of the bullet projecting beyond the mouth of the case, and fitting with almost a push fit into the cylindrical portion of the bullet seat. Then the bullet seat straightens the bullet up so that its axis is in line with the axis of the bore, and thus on discharge the bullet slides straight forward into the bore and rifling without any wobble or jump which might tend to deform the bullet.

That portion of the chamber corresponding to the neck of the case should be a little longer than is necessary from the measurement of the cartridge. That is about 1/32 to 1/16 inch should be allowed for the lengthening of the neck of the case, and the shoulder of the chamber ahead of the mouth of the case should be pushed forward correspondingly. Cases lengthen considerably when fired, particularly cases which have been reloaded a number of times, and the chamber must allow for this, or it will actually crimp the cartridge just as a reloading tool does, and thus may lead to ragged shooting or even to excessive pressure.

Only experienced tool-makers have the art and skill necessary to make chambering reamers. Such a man will readily understand the instructions and explanations herein. If the gunsmith is not also a tool-maker he will be obliged to have his chambering reamers made for him, preferably by a firm of rifle barrel makers. The making of a set of chambering reamers is expensive work. Besides the time of the designer, and of the workman, much machine time is necessary, and thus the cost of making one complete set of reamers and the accompanying headspace gages will run somewhere between

$150.00 and $300.00, for a modern bottle-neck rimless cartridge. Reamers for simple, straight pistol cartridges are very much cheaper. Figure 113 shows several chambering reamers complete with pilot and shank.

Starting with the first or smallest reamer, each in turn is run in and turned, cutting out until it has entered into the bore up to its stop. Then the next is run in, and so on, using light oil, and clearing all chips from the chamber between each operation, thus gradually enlarging and shaping up the chamber until finally it is in semi-finished shape, lacking perhaps .003-inch of its finished diameter, and about .02-inch of being deep enough. At this point the barrel should be screwed into the receiver, if that has not been already done, the barrel having been threaded and the breech end faced and cut for the extractor, lugs, etc., before the chambering was started.

HEAD-SPACING: Here we must explain the very important matter of headspace. It will be obvious to all that the chamber must hold the cartridge back against the face of the bolt, and must support the cartridge and its primer firmly against the blow of the firing pin. Few gunsmiths, however, realize how accurately headspace must be adjusted in order that the rifle shall operate efficiently and safely. When a rimmed cartridge is used, the headspace is the distance from the shoulder of the chamber on which the forward surface of the rim of the cartridge rests to the face of the breech bolt or breech block. See "A," Figures 114-D. This distance must be equal to the length, that is the thickness from front to rear, of the rim of the maximum case. No tolerance should be allowed, and this distance or headspace is cut carefully and gradually with the finishing reamer, after the barrel and breech bolt have been assembled to the receiver, with constant trying of the headspace gage or of a cartridge known to be of fairly maximum dimensions. In the case of a rimmed cartridge the headspace gages are merely dummy cartridges very accurately turned of steel, the smaller or "GO" gage being exactly the size and shape of the maximum cartridge, and the "NO GO" gage being just a trifle larger or longer in length, with a rim which is approximately .003-inch thicker than the rim of the maximum case. The finishing reamer is run in until the breech block will just barely close, without undue effort on the bolt handle or finger lever, on the "GO" gage, but the action positively must not close on the "NO GO" gage or the rifle will be both unsatisfactory and unsafe. The exact dimensions of the finishing reamer assure that the shoulder, and bullet seat of the chamber will all be at the right distance ahead of the rim seat, and that all portions of the chamber will have the correct diameters.

The headspacing of a chamber for a rimless cartridge is slightly different, and it is also more important because as a rule rimless rifle cartridges are used with much higher breech pressures than rimmed cartridges. Here it is the shoulder of the chamber just in rear of

the neck which holds the head of the case back against the breech block and supports the case and primer against the blow of the firing pin. The headspace is thus that distance from some selected point on the cone of the shoulder to the face of the breech block or breech bolt. See "A," Figure 114-C. Finish chambering is done in the same way as with rimmed cartridge, the receiver and bolt assembled to the barrel, and the finishing reamer being run in until the bolt will just barely close on the smaller or "GO" headspace

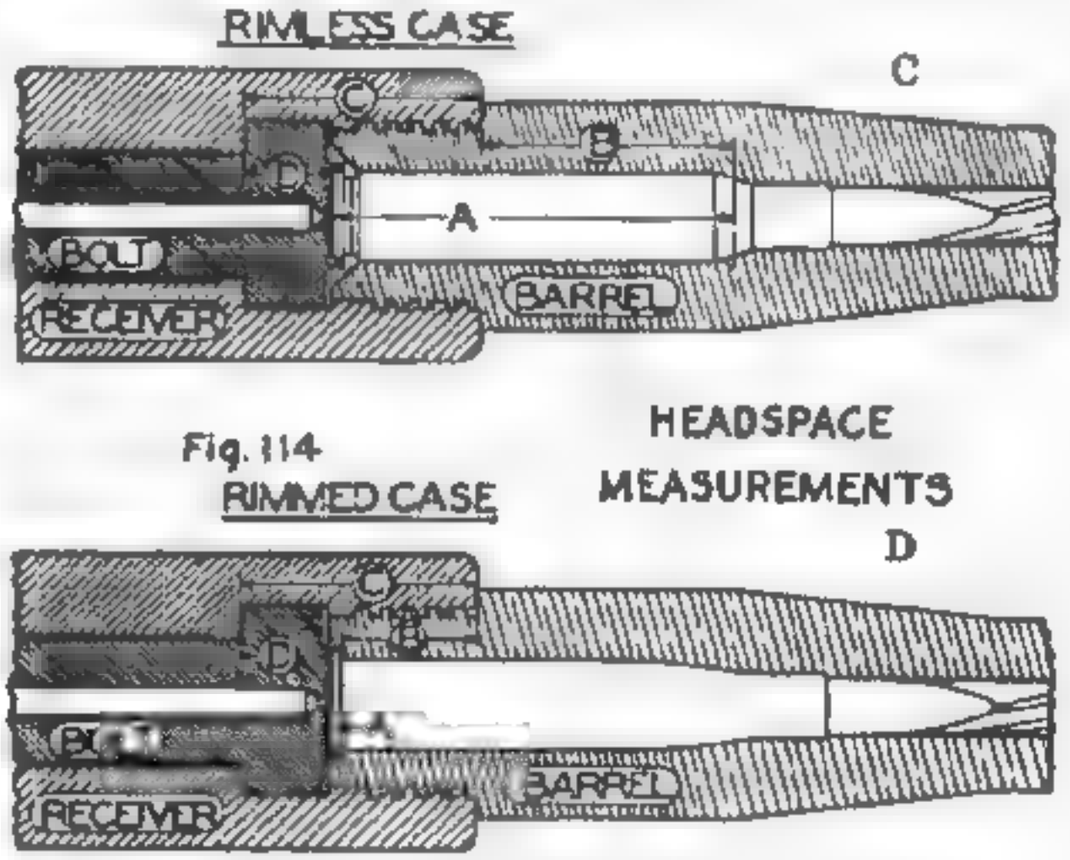

Fig. 114 HEADSPACE MEASUREMENTS

gage. The bolt handle should turn down on this gage with just a slight suspicion of feel, but not so hard as to cause any difficulty in operating the rifle and having the cartridges insert easily in rapid fire. At the same time the bolt should not close down completely on the "NO GO" gage. Figure 115 shows the two headspace gages, "GO" and "NO GO" for the Springfield rifle.

The minimum headspace gage for the .30-06 rifle and cartridge is known at the 1.940 gage, that being its length from a determined point on the cone to its head. The bolts of all rifles for .30-06 cartridges, military or sporting, must close readily on this gage. The "NO GO" gage for arsenal use is known as the 1.946 gage, being .006-inch longer than the minimum of "GO" gage. Bolts of rifles issued from arsenals must not close completely on this gage. The "NO GO" gage for rifles in the hands of troops is known as the 1.950 gage. If bolts of rifles in the hands of troops or in storehouses at posts close on this gage when they are inspected such rifles are

withdrawn from use and issue, and are sent to an arsenal for repairs.

Headspace gages, as a rule, cannot be bought, but must be made by the gunsmith, or by the man who makes the chambering reamers, from ground and hardened steel. When a gunsmith has a number of barrels of a given caliber to chamber or fit he should certainly have a set of gages for that caliber. He is then prepared to fit ready made and chambered barrels of that caliber to any breech se-

tion. For example, if he has a set of such gages for the .30-06 cartridge he may buy his barrels ready chambered and threaded from the several sources of supply for such barrels, and he can then screw these barrels directly to his receiver, and then he can proceed to try different bolts in that rifle until he finds one bolt which will close down on the "GO" gage, but will not close down on the "NO GO" gage. That barrel, receiver, and bolt are then perfectly satisfactory and have the correct headspace.

But if the gunsmith has but one barrel to fit he may be able to get by with it all right by using a loaded cartridge as a gage. Procure a number of cartridges of different makes of the caliber desired. Select from this lot by trial in another new rifle of standard make the two cartridges which appear to be the largest and longest. It will be difficult or impossible to measure their length from shoulder to head if they are rimless cartridges, but one will probably be able to tell by the way they feel when they go in the standard rifle, and the way the bolt closes on them. Use one of these for the "GO" gage. Paste a disc of paper .005-inch thick, on the head of the other and use it for the "NO GO" gage

The gunsmith, and all riflemen in fact, must beware of the ready chambered and threaded barrel. It cannot be stated too strongly that rifle barrels cannot be made strictly interchangeable, and that the only way a ready made and completely chambered and threaded barrel can be safely fitted to a rifle is by changing breech bolts until one is found which fits tightly enough (and not too tightly) to successfully pass the gaging test, or by carefully fitting the breech block or bolt in an unfinished state, machining or grinding it to a perfect fit with the gage.

The reason why barrels cannot be made to be interchangeable is shown in Figures 114-C and 114-D. To assemble interchangeably it would be necessary that the sum of the measurements B, C, and D be not greater than the difference between the minimum and maximum headspace permissible. But in production no one of these measurements can be assured closer than, say, .003-inch. Thus, if in a given barrel and receiver and bolt, these three measurements were all maximum, or all minimum, we would have an aggregate of .009-inch, whereas in most rifles the maximum permissible difference between max. and min. headspace is about .006-inch. The barrel is therefore always finish chambered after being assembled to the receiver and bolt in connection with the headspace gage.

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It therefore follows that it is extremely important that only that particular bolt and no other be used in that rifle. Considerable trouble, and some serious accidents have happened due to changing bolts. For example, the bolts of most high power bolt action rifles, and also of many .22 caliber bolt action rifles, will apparently interchange very nicely to the uninitiated. The bolt of any rifle will fit nicely into any other rifle of that make and caliber, and the tyro thinks that everything is all right. But the use of that bolt in that wrong rifle may give poor accuracy (particularly in the case of .22 rifles), or it may cause the cartridge cases to separate in two about half an inch in front of the head, leaving the forward portion of the case wedged in the chamber, or if the cartridge be a little overloaded or if the case have a soft head from too much annealing in the cartridge plant the head of the case may give way, permitting gas to come to the rear, completely demolishing the breech action and perhaps seriously injuring the shooter. On the other hand, modern military bolt actions made of properly heat treated alloy steel like the Springfield, Winchester Model 54, Remington Model 30, Mauser, and Mannlicher, which are designed to stand a regular working pressure of 48,000 pounds per square inch, will successfully withstand an accidental pressure up to 100,000 pounds per square inch without anything giving away provided that the headspace is correct, and that the cartridge case is in good condition. It is the rarest thing in the world to find a soft headed cartridge case in the product of our standard cartridge manufacturers—that is, their peace time product. Practically all the soft headed cartridge cases we have found have been in war time ammunition, such ammunition being made in enormous quantities with brass which was not quite up to that which the cartridge companies can always assure in times of peace.

While we have emphasized the danger of excessive headspace, we do not wish the reader to suppose that great numbers of rifles are unsafe. Headspacing is very important from the standpoint of safety, but it is also a very simple little test, taking not more than a minute to make if one has the proper gages. The product of our large arms companies, of many of the smaller made to order firms, and of many of our most prominent gunsmiths is all properly headspaced, and these weapons are absolutely safe if used with any standard cartridge of the correct caliber made by any of our large cartridge companies or by the Government arsenals, or with hand loaded cartridges assembled with the loads recommended in the Ideal Handbook or in the book "Handloading Ammunition" by J. R. Mattern.

We must also speak of too small or too short headspace, because that also is likely to occur, although it is not accompanied by such grave consequences as excessive headspace. If we have too small headspace then the breech block or bolt will fail to

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close down on the cartridge, or it may close down on cartridges of one make, but not on those of another. The chamber is just too short, and the remedy is to run the finishing reamer in a little deeper or to select a shorter bolt. Once in a while, in using reloaded ammunition, the rifleman may run into similar trouble due to the stretching of fired cartridge cases. The fired cartridge cases one reloads may have stretched too long for that chamber. This often occurs in lever action rifles using cartridges giving high breech pressure, particularly in .250-3000 and .300 Savage cartridges in Savage Model 1899 lever action rifles, and in .30-06 cartridges in Winchester Model 1895 rifles. These breech actions, not having bolts locked at the front, and not being made of hard, heat treated, alloy steel, have a certain amount of spring or give to them, and the cartridge cases fired in them lengthen so much that they cannot be resized to again fit easily into the chamber in which they have been fired.

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CHAPTER 17

RIFLE CARTRIDGE DESIGN

IF you essay to build a rifle of your own, or, if you are a professional, one for a patron, it is probably because no existing model quite meets your ideas. Naturally you want this new rifle to represent the very highest type, and that may even involve carrying out your own ideas as to a cartridge. Now in times past we have seen both amateurs and professionals air their views as to cartridges. Some of these views are excellent, some fair, while many violate almost every rule of good ordnance design and would be complete failures were they carried into execution. This chapter is therefore going to be devoted to illustrating certain principles of cartridge design to the end that your ideas as to cartridges may be sound. Knowledge in this respect will also help you in your understanding of the proper design of rifle barrels, bores, and chambers.

First we want to explain briefly HOW RIFLE CARTRIDGES ARE MADE. Particularly we wish to show what an intricate matter the making of a cartridge is, and what an expensive outlay in tools is necessary before any change can be made.

Take first the making of the brass cartridge case. Cartridge brass comes from the mill in long sheets or strips about 6 inches wide, many feet long, and of the thickness desired, depending upon the particular cartridge. This brass strip is first fed into what is called a double action press where a round disc is first cut out of the strip, and the disc then formed into a shallow cup by means of a punch and die. The cup then passes in succession to a number of other presses, also provided with punches and dies in which it is gradually drawn out into a long cylinder or tube, closed at one end—the head. The presses are big, heavy, strong machines. No hand tools could possibly do such work. The punches and dies have to be made with extreme accuracy, and are cut, hardened, and ground by tool-

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makers specially skilled in such work. No mere machinist has the skill to make such dies.

One of the properties of brass is that when it is worked or drawn through a die it becomes hard, and several draws in succession would make it very brittle. Therefore, between every draw the cups or tubes are sent to a gas or electric furnace where they are heated red hot to a certain exact temperature to soften or anneal them, and after each anneal they are washed and dried before they are sent back to the next press. Figure 116 and Figure 117 shows the

various stages that the cartridge case goes through from the original cup, through the various draws, and the trimming, heading, and necking operations, to the finished case. When the cup is drawn out into a long enough tube the ragged mouth is trimmed off, and then it goes to a series of machines called headers which form and stamp the head of the case and form the primer pocket and the rim. If it is a rimless case another machine like a little lathe cuts the extracting groove. Up to this point the case body is straight with no neck. The case next goes to a press which necks it down gradually in four or five sets of punches and dies with several neck anneals in between, these annealings being localized so as to leave the head of the case hard and the neck rather soft. Finally, after the last necking operation, the neck of the case is usually given a last neck anneal to assure that the neck shall have the exact grain structure which will assure against season cracking as the cartridge gets old.

In all these thirty-odd operations it is necessary that the anneals be very carefully controlled in order that the brass shall have just the right grain structure as will insure the required strength, toughness, life and temper. To this end each cartridge plant employs a metallurgist skilled in non-ferrous metals whose duty it is to inspect to insure that each operation and anneal is to the required kind, length, or temperature to give the desired property to each case or complete cartridge.

The sets of dies, punches, tools, etc., to form one case or one bullet cost several thousands of dollars, while the sets of presses, headers, trimmers, cutters, bullet machines, loading machines, etc., to make cartridges, cost into the hundreds of thousands of dollars.

Figure 118 shows the various stages in THE MANUFACTURE OF A MODERN JACKETED BULLET. The bullet jacket is drawn from a sheet of gilding metal (copper 90 per cent., zinc 10 per cent.) in much the same manner as the brass case is drawn until it is finally completed, being formed at one end and open at the other. In the meantime the lead core is being formed. A large ingot of lead of the required mixture, usually lead, tin and antimony, is placed in a huge extruding press, from which a long wire of lead is extruded. This wire is then fed into a press in which it is cut off into short lengths, and formed into the required

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shape for the bullet core. The completed jackets and cores then go to a bullet assembly machine where the core is first inserted into the jacket, and the assembled jacket and core then pass in succession through a number of dies in which the bullet is shaped and swedged into the required shape and size.

In all of these operations exact shape and size are of extreme importance. Punches, dies, and other tools must be most uniformly and accurately made, and as they are worn they must be replaced to assure that the completed cartridge will come within the tolerances shown in Figure 112.

CARTRIDGE ASSEMBLY: Finally the completed cases and bullets go to the loading room where, with powder and primer, they are assembled into complete, loaded cartridges by operations very similar to those which are performed by the Ideal, Bond, or Belding and Mull hand reloading tools, except of course that there is one big automatic machine which does all the operations in turn and loads about 2,000 cartridges per hour.

It should be understood that through all the operations there is very complete inspection, mechanical, physical, chemical, and visual, to assure that each case, bullet and complete cartridge shall be safe, correct size and material, etc. For example, usually each morning and afternoon a batch of bullets are taken direct from the bullet assembling machine, and sent to the proof house where they are immediately hand loaded into cartridges and fired to see that they are accurate and give the required velocity and pressure, and thus insure that the bullet machines continually turn out first class bullets. Also each cartridge after loading is mechanically weighed to see that none contains too much or too little powder.

From all this it will readily be seen that it is a very expensive matter to tool up TO MAKE A SPECIAL CARTRIDGE. No cartridge company can possibly afford to do it unless they can foresee a ready sale of at least several hundred thousand of such cartridges yearly. Therefore the amateur or professional gunsmith is obliged to confine his alterations in design to such slight changes or adaptations that he can make in existing cartridge cases or jacketed bullets.

Let us say, for example, you want a 7 mm or .25 caliber cartridge, but no existing one has just the required shape or powder capacity, so you decide to take a larger case, say a .30 caliber case, and neck it down to the desired caliber. Or you may even wish to cut it off shorter, reshape its neck, or otherwise alter it. Right here we must interpose a few words of caution. We have already seen in the chapter dealing with rifle chambers, how necessary exact headspace is, and how with a rimless case the shoulders of the case and chamber assure this headspacing. The entire rimless case must therefore be extremely exact in size and shape or we will have a lot of trouble—perhaps extremely dangerous accidents. No ordinary

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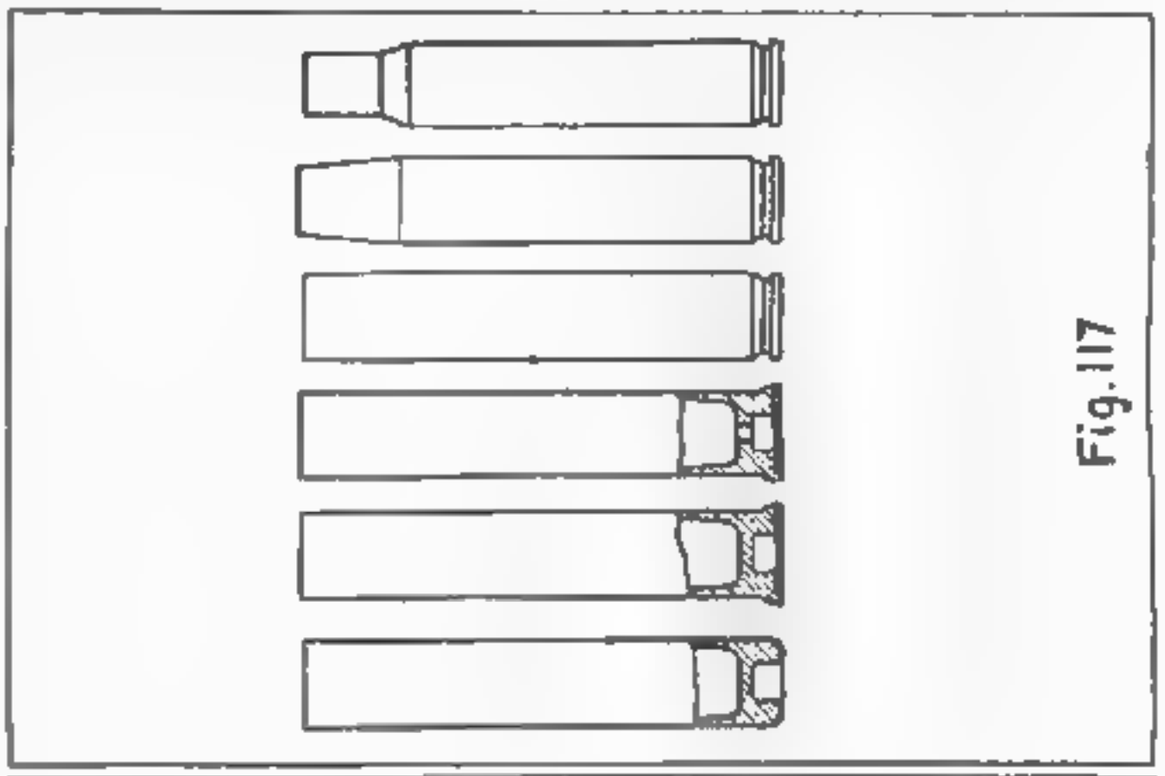

Fig. 117

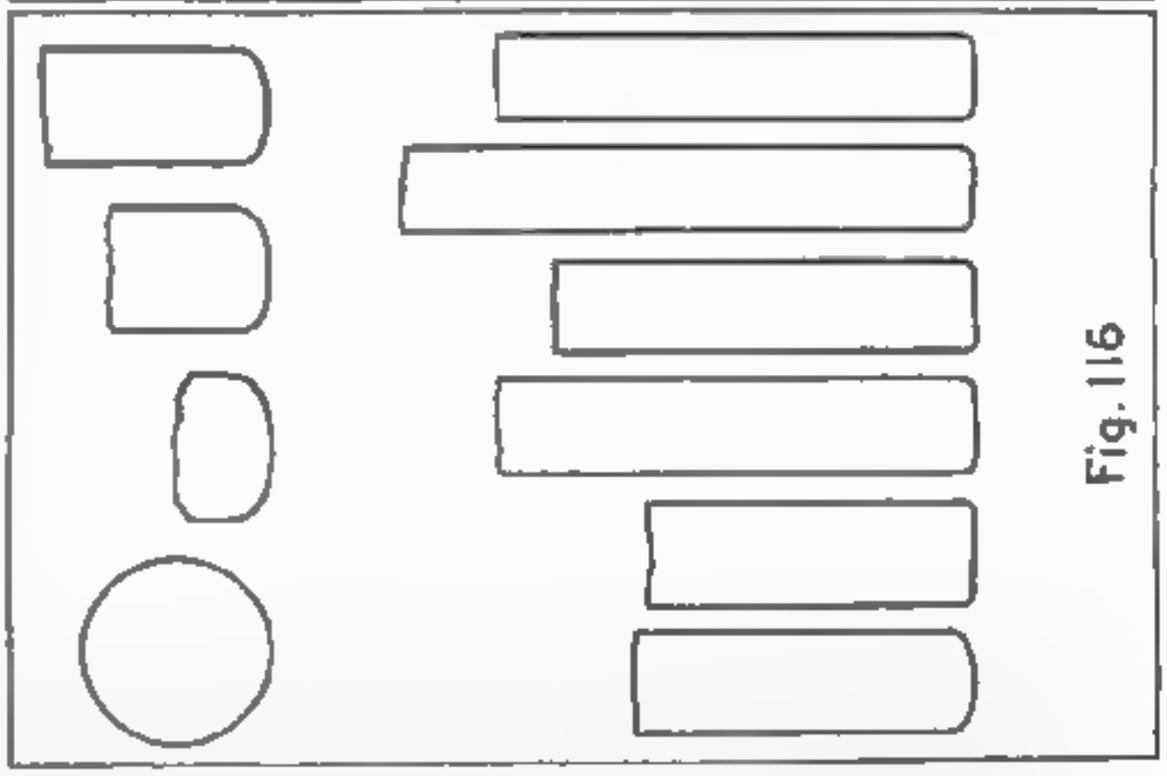

Fig. 116

machinist is capable of making dies accurate enough to neck down or reform rimless cartridge cases, and let no one suppose that such work can possibly be done on hand presses or with hand reloading tools. It must not be attempted.

The necking down of a rimmed cartridge case, however, is an entirely different proposition. Here the rim of the cartridge insures the correct headspacing, and if the hand made dies do not form the shoulder and neck of the case to absolutely exact dimensions, a

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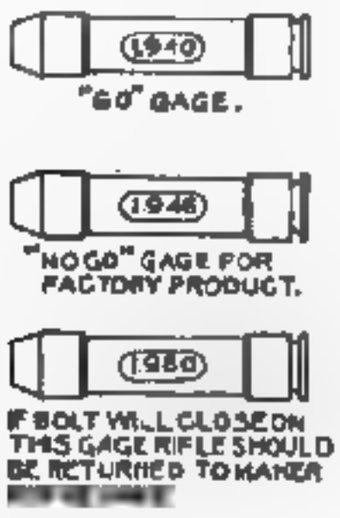
light charge fired in that case in the rifle will usually swell the reformed cartridge to exactly fit the chamber and thereafter all will be well. In this way one can neck down existing cartridges to other calibers and shapes, of which the following will serve as examples:

.38-55 necked to .35 or .33 caliber
.30-40 or 30-30 necked to .28 or .25 caliber
.25-35 or .25-20 caliber necked to .22 caliber
.25-35 expanded to 6.5 mm—etc.

Suppose we wish to neck the .30-40 Krag case to .25 caliber. First we make a drawing of the finished case we wish. Then we make a series of dies to neck the case down gradually, and we must anneal the neck between each necking operation or the neck would



HEAD-SPACE GAGES. .30-06 CARTRIDGES.

Fig. 115

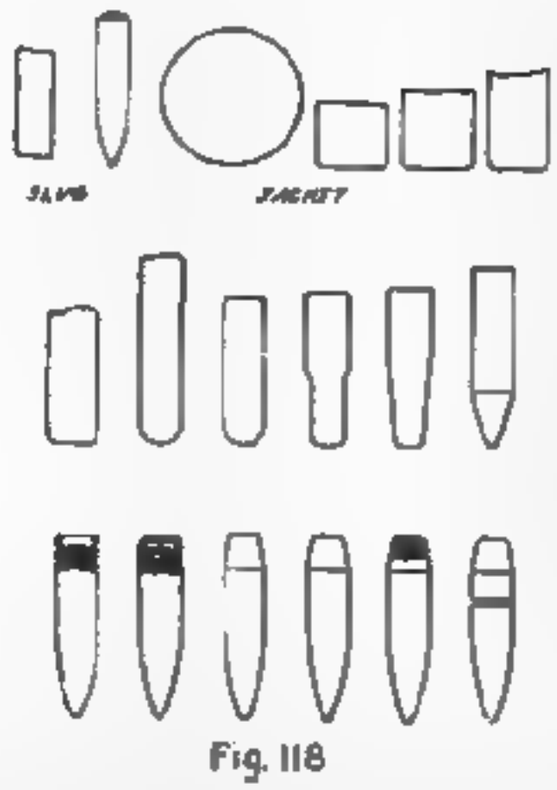


Fig. 118

get too brittle or hard. The first die necks the case down to perhaps .290 caliber, the second to .275 caliber, the third to .265 caliber, and the last die completes the reforming and necking so that the neck now measures .255-inch inside and both neck and shoulder are the required shape and length outside. (.25 caliber bullets usually measure .257-inch, and neck for a jacketed bullet should be .002-inch smaller than the bullet to hold it friction tight in the case.) As you neck a case down the brass in the neck is compressed and must go somewhere. Consequently the neck of a case necked down from .30 to .25 caliber will have a thicker wall than the original .30 caliber case had. For this reason the final die must be cut gradually with much experimenting until a size is arrived at which makes the neck of the case measure just .255-inch inside.

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The cases are forced into and pulled out of the dies either in an arbor press or in an Ideal bench loading armory press. The ordinary hand reloading tool is not nearly strong enough nor accurate enough for these necking operations. Between each operation you must anneal the neck. Hold the *neck only* of the cartridge in a properly shaped gas flame so that it will just come to a dull red heat in about 10 to 20 seconds. This is best done by arranging two gas burners, each of which plays a pencil shaped flame about 1/8-inch in diameter on opposite sides of the neck. The neck is held between the two flames until it just begins to glow red hot which it should do in about ten to twenty seconds. Then it is allowed to cool, then washed in hot soapsuds and water, then boiled in clear water, taken quickly from boiling water, put hot in a wire strainer, and shaken above a stove or gas burner so as to cause the cases to dry completely within three or four minutes after being taken from the boiling water. The cases can of course be washed and dried in large batches. The neck of each case is then finally wiped with a slightly oily rag before being forced into the next die. After the last necking operation it is best to clean the entire case with acid, wash, and dry as explained in the Ideal Handbook. In many cases after necking in this way it is necessary to trim the mouth of the case so that it will have a uniform and desired length. This is best done in a lathe with a special fixture and cutter made to trim to exact neck length.

The overall length of a cartridge case from head to mouth should be from 1/32 to 1/16-inch shorter than the chamber. Rather it is better to say that when a new cartridge is in the chamber of the rifle there should be about 1/32 to 1/16-inch between the mouth of the case and the shoulder of the chamber just ahead of the mouth. This is particularly necessary where one is going to reload his fired cases because cases, as they are fired and resized at the neck, get longer in the neck, and if there is not some length tolerance between case mouth and forward shoulder of the chamber the case will soon become too long so that the breech bolt will not close on it, or if it does close, it will crimp the case on the bullet in a way that may tend towards very high breech pressures.

Turn now to Figure 119 while we explain certain of the details of MODERN CARTRIDGE DESIGN. "A" is the old fashioned straight taper rimmed cartridge of black powder days. The outside of this case must have a slight taper from rim to mouth otherwise it would stick badly in the chamber and would be very difficult to extract. This cut shows the bullet seated deeply in the neck of the case.

The depth to which a bullet must be seated in its case depends upon the throat of the rifling, the shape of the ogive and bearing of the bullet, and on the length of the magazine of the rifle. In a cartridge like the .38-55 for example, it is necessary to seat the

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bullet as deeply as shown in "A", if the cartridge is to work through the magazine of repeating rifles and in factory cartridges the bullets are seated as deeply as shown. But this deep seating does not result in the best accuracy because the bullet cannot extend up into the throat of the rifling in such a manner that the throat will hold the bullet into almost exact centering with the axis of the bore. For use in single shot rifles it is better not to seat the bullet so deeply and it can usually be left to protude 1/8 to 1/4-inch further out of the case or enough so that the ogive of the bullet will just touch the beginning of the lands when seated in the chamber.

Cut "B" shows how Cut "A" could be modernized somewhat. Here the bullet is not seated nearly so deeply in the case, and quite a long portion of the cylindrical bearing of the bullet extends out beyond the mouth of the case. The throat of the chamber should be cut for this shape and projection of the bullet so that the cylindrical portion of the bullet is almost a push fit in the throat. The magazine of course must be long enough. Also in order that the cartridge may be secure, the bullet firm in the neck and waterproof, the base of the bullet should be seated at least a diameter deep in the neck. That is, a .38 caliber bullet should be seated at least .38-inch deep in the neck; a .25 caliber bullet at least .25-inch deep.

Next turn to Cuts "C" and "D." These show bottle-necked, rimmed cartridge cases. "C" has a much more abrupt shoulder between body and neck than is desirable. An abrupt neck gives a poor shape of powder chamber that churns up the powder gases too much, increases chamber pressure, and the powder does not burn as uniformly as it would in a more gradual slope of shoulder. "C" also has a much longer neck than is necessary. Many of the older bottle neck cartridges have these two faults. Cut "D" shows a much better design of shoulder and neck. The shoulder is of much more gradual taper and is carried further forward thus shortening the neck and at the same time giving a larger powder capacity than in "C."

In considering THE NECK OF THE CASE we must think of the bullets we are going to use. The neck should be just so long that the base of the longest bullet will not extend to the rear beyond the neck into the powder space. Suppose we are designing a .25 caliber cartridge in which we intend to use 87, 100 and 117 grain bullets. We cut the throat of the chamber just correct for the 87 grain bullet when that bullet is seated .25-inch deep in the neck. To fit this throat the points of all the other bullets must extend the same distance outside the mouth of the case that the 87 grain bullet does. When seated thus there will be quite a length of the 117 grain bullet inside the neck of the case, and the neck must be just long enough so that the base of the 117 grain bullet will come just flush with the rear of the neck.

Cut "E" shows a rimless case. Here too the same remarks apply

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with regard to the slope of the shoulder and length of the neck as with "C" and "D," only we cannot have as gentle a taper of the shoulder as is possible with a rimmed case like "D" because our shoulder with the rimless case must be abrupt enough to surely hold the head of the case against the blow of the firing pin and insure correct headspace. Cut "E" has been carefully drawn to show the gentlest slope that is permissible with a rimless cartridge case.

A RIMMED CARTRIDGE CASE is a very great advantage. It solves lots of problems for us, and greatly simplifies both cartridge and rifle design and manufacture. It is much safer than the rimless case. The rimless case is a necessary evil forced on us by magazines similar to the Mauser magazine and it is the logical case for assembly in clips. We cannot use cartridges of the rimmed type in the Mauser magazine and load with a clip because to have the cartridges feed properly from the magazine the rim of an uppermost cartridge must be in front of the rim of the cartridge immediately below it. Therefore the rimless case is necessary in all rifles having magazines similar to the Mauser, Springfield, etc. Were it not for this there would be no rimless cases. The chambering

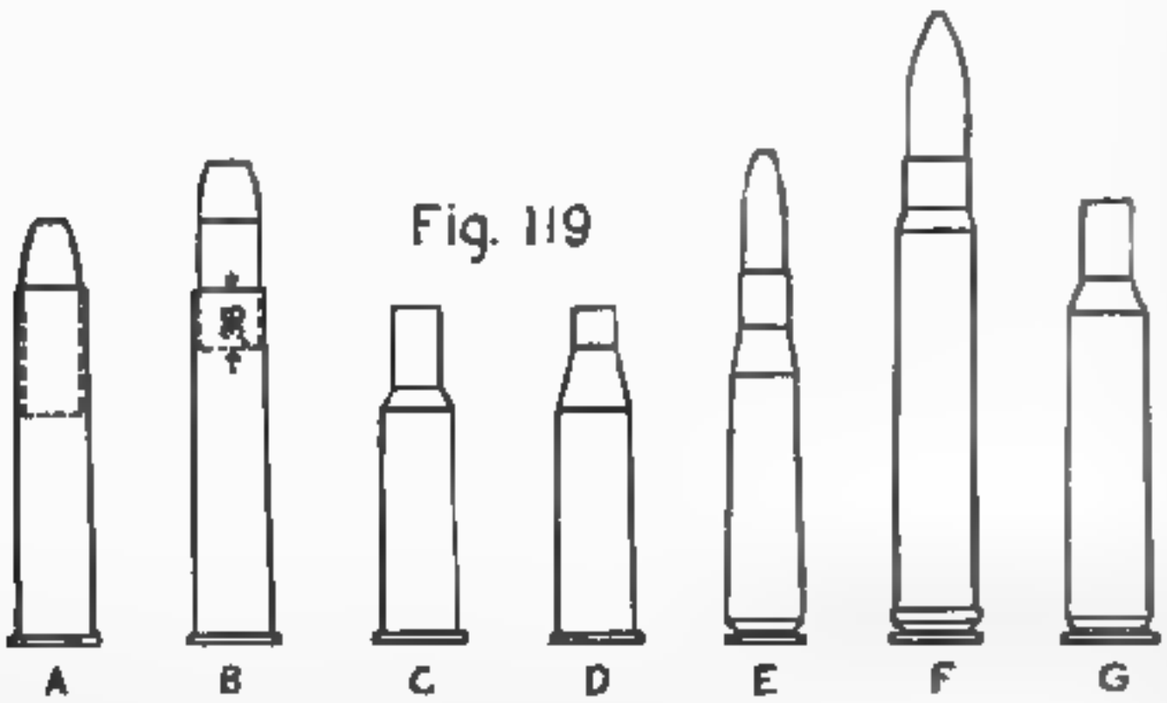

Fig. 119

A B C D E F G

of a single shot rifle for a rimless case is always a grave mistake. The design and making of an efficient rimless case extractor for such an action is difficult, and at the best such extractors are not nearly as sure in action as rimmed case extractors.

In order to get away from the disadvantages of the rimless case, THE BELTED CASE has been designed, and was first made popular by Messrs. Holland and Holland of London. It is shown in Cut "F." The shoulder ahead of the extracting groove which

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holds the head of the case back against the face of the bolt, supporting it against the primer blow, and assuring correct headspace, measures .02-inch and is not so large as to interfere with one cartridge sliding smoothly over the cartridge just below it in magazines of the Mauser type.

Cut "G" is THE SEMI-RIMLESS TYPE, of which the .280 Ross and the .401 Winchester self-loading cartridges are types. In this case the rim stands just enough above the body of the case to permit of its seating against a shoulder like the rimmed case, but not enough to prevent upper cartridges from sliding smoothly over the lower cartridges in Mauser type magazines, the extractor being of a type similar to those for rimless cartridges.

The POWDER CAPACITY of a cartridge case must be correct in size for the proper charge of an existing and suitable powder which will give the muzzle velocity desired within the limit of the permissible working pressure of the rifle, and also the limit of proper burning pressure of the powder.

In general it may be said that the LIMIT OF PERMISSIBLE PRESSURE in lever action rifles is about as follows:

Winchester Model 94 and 86—38,000 lbs. per sq. in.
Winchester Model 95 and single shot—44,000 lbs. per sq. in.
Savage Model 1899—44,000 lbs. per sq. in.

The limit for the Krag rifle, and for the .303 Lee Enfield is about 41,000 pounds, while the limit for modern bolt actions made of heat treated alloy steel with locking lugs at the head of the bolt, like the Springfield, Mauser, U. S. Model 1917, Winchester Model 54, Remington Model 30, and Ross, is 48,000 to 50,000 pounds per square inch.

Cartridge cases also have their limits in pressure. The older cases like the .30-30, .32-40, .38-55 and .33 W.C.F., were neither by their design nor their anneal made to stand extremely high pressures and they should not be loaded to pressures higher than about 40,000 pounds per square inch, and neither should they be necked down to make other cases to stand higher pressure.

The various kinds and granulations of SMOKELESS POWDER have high and low limits which should not be exceeded. With any of our rifle powders, when the pressure is over about 50,000 pounds a point is soon reached where even one grain additional charge will cause the breech pressure to sail to a very dangerous figure. Hi-Vel powder will burn cleanly and well at pressures as low as about 25,000 pounds, while if du Pont No. 17 1/2 powder were used at a pressure much below 34,000 pounds, it would not burn cleanly, there would be many unburned grains, and the fouling might be highly corrosive. Any powder, even Hi-Vel, may act in this manner if fired at pressures well below its minimum efficient working pressure.

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Take, for example, the various .30 caliber cartridges. The .30-30 cartridge with 165 grain bullet has just enough capacity so that a charge of a finely granulated and relatively quick burning powder can be used to give a muzzle velocity of about 2150 to 2200 f. s. That is about the limit for that case and bullet. With a lighter bullet a still higher velocity can be obtained until we come to the point where the bullet is so light that it will not give enough resistance to develop a pressure which will cause existing and suitable powders to burn cleanly. The .30-40 Krag cartridge with more powder capacity has a limit of pressure plus velocity which, with existing powders, will permit of giving a 220 grain bullet M. V. 2150 f. s., or a 110 grain bullet M. V. 2800 f. s. The .30-06 case permits us similarly to speed up a 220 grain bullet to 2375 f. s. or a 110 grain bullet to 3400 f. s. And the largest case of all, the .30 Magnum, makes it possible to fire the 220 grain bullet at M. V. 2525 f. s. or the 180 grain bullet at 2850 f. s.; but the 110 grain bullet would be unsuitrd because it will not give sufficient resistance to burn existing powders cleanly in such large charges.

Where one wishes very high velocity combined with the burning of existing powders under conditions as will insure the highest degree of accuracy, the present thought is that for various calibers the cases should have about the following powder capacity:

.30 Caliber—.30 Magnum case
7 mm. —.30-06 case
.25 Caliber—7 mm. case (.25 Roberts)
.22 Caliber—.25 Rem. Rimless case

BULLETS: The modern metal jacketed bullet should be jacketed with gilding metal (copper 90%, zinc 10%) or with Lubaloy which is gilding metal with about 1 per cent. tin added. Pure copper jackets may also be used. Cupro-nickel jackets may be regarded as obsolete. The objection to them is that at muzzle velocities over 2100 f. s. they give a lot of trouble by depositing metal fouling in the bore. Below 2100 f. s. there is no objection to them.

Where the highest degree of accuracy is desired, modern bullets should be of such length and shape that at least one caliber of their length can be inserted within the neck of the case, and one caliber length of their bearing remains outside the case to permit of centering by the throat of the chamber. Of course other things also must be attended to, such as pitch of rifling, proper muzzle velocity, pressure, etc.

The best bullet for any rifle is one with a flat base. Boat-tail bullets present no advantages for use in rifles. Theoretically they give slightly less pressure, can be loaded to slightly higher velocity within the limit of permissible pressure, and have a shape which makes for slightly greater remaining velocity. But these very slight

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advantages are more than offset by the facts that such bullets cause more erosion and wear the barrel out quicker; that unless they are extremely well made they do not shoot as accurately as flat base bullets, and that it is difficult to seat them so that there will be enough of their bearing inside the case neck for security and outside case neck for accuracy. The only reason why a boat-tail bullet is used in the .30 caliber M.1 new service cartridge is that this same cartridge is used in both rifles and machine guns. In a rifle we care nothing about what happens to the bullet after it passes 1,000 yards, but in a machine gun we desire a cartridge, the sheaf of fire of which can be controlled to the longest possible range, and the boat-tail bullet presents a great advantage in this respect.

The reader who desires to go into more detail with respect to rifle ammunition is referred to the "Ideal Handbook" published by the Lyman Gun Sight Corporation, and the book "Handloading Ammunition" by J. R. Mattern. In fact these books are essential for every gunsmith or shooter doing any work whatever with rifles.

PROOF FIRING AND PROOF CARTRIDGES: There is one matter regarding cartridges which is of extreme importance to gunsmiths, both amateur and professional. Whenever a new rifle is built, or a new barrel fitted to an old rifle, or any work connected with chambering or fitting breech bolts is done, the complete and finished rifle should be proof fired with a cartridge giving a higher pressure than any factory cartridge or reloaded cartridge that will thereafter be used in the arm. This should be done before the rifle leaves the shop. It is a matter of proper prudence, for one cannot surely tell whether or not there is some little flaw or mistake somewhere which might render the weapon decidedly unsafe, even with

quite normal ammunition. Particularly the professional gunsmith should always proof fire every weapon on which he does any work connected with barrel or breech, and he should keep an exact record of headspacing and proof firing of that weapon for future reference. The purchaser also has a right to expect, and should know that his rifle has been properly proof fired.

The rifle is placed in an extemporized rest, arranged to take up recoil, and is loaded and fired with a proof cartridge. It should be fired from a distance by means of a string, with operator under cover. Then inspect the rifle carefully to see that nothing is broken, cracked, upset, or deformed. Test with headspace gage again and see that the chamber has not been enlarged.

For these purposes the arms and ammunition manufacturers have SPECIAL PROOF CARTRIDGES made with which to test their product. These cartridges are made with cases much thicker than ordinary, and are usually nickel plated or blackened so that they will not be mistaken for regular cartridges. They are usually loaded with a charge of powder and a bullet which will give a breech pressure about twenty-five to fifty per cent. in excess of the

pressure of the heaviest regular cartridge made in that caliber. Such proof cartridges can scarcely ever be obtained by gunsmiths, and they will usually have to load their own. Use new primed cases that have never been fired before, and load them with the heaviest bullet to be regularly used in the particular rifle, and a charge of powder about two grains heavier than the powder company recommends as the maximum charge for that particular rifle, cartridge, and bullet. This will give a pressure of from 2000 to 5000 pounds per square inch higher than the permissible regular working pressure for that rifle, and should prove a practical and easily prepared proof cartridge. E. I. du Pont de Nemours & Company, Wilmington, Delaware, and the Hercules Powder Company, Wilmington, Delaware, will mail on request little leaflets showing all the recommended charges of the powders they manufacture for various calibers of rifles, sizes of cartridges, and weights of bullets from which one can select the maximum charge and increase it by two grains weight of powder. But be particularly careful never to get these proof cartridges, or "blue pills" as they are often called, mixed with regular cartridges for obvious reasons.

Chapter 18

STRIKING AND POLISHING BARRELS AND ACTIONS

IN the remodeling of old guns, as well as in the manufacture of new ones, the polishing of the metal parts prior to bluing or case-hardening is one of the most important phases of the work. On this "white" finish depends the final appearance of the weapon. Amateur workmen seem to have the opinion that the bluing or hardening will "cover up" scratches or spots in the steel, while just the opposite is true. Any marks which show before bluing or hardening will show still plainer in the finished job.

The degree of polishing necessary depends entirely on the kind of finish wanted, whether bright, or dull matte. Whichever is chosen, however, the polishing must be done evenly all over, and the "grain" of the work must all run in the same direction. You may have a barrel polished perfectly, then one little swipe with the abrasive cloth away from the direction of previous work, will make a glaringly ugly streak in the bluing.

In most cases, before a barrel can be polished it must be "struck." STRIKING is merely another term for draw-filing, which as most mechanics know, means holding the file at right angles to the work, and pulling it back and forth, much as a carpenter uses a draw-knife. (See Figure 120).

This striking is necessary for the removal of dents and scratches in old barrels which are too deep to be removed by polishing. It is vitally essential in the remodeling of "as issued" Springfields and other military arms on which the barrels are merely rough turned without any finishing cut. For these extremely rough barrels, unless they are turned down in a lathe, as explained in Chapter 15, a special method of striking is necessary, which will be explained later.

In factories, when a new barrel comes from the machine which turns it to the required taper and form, it is usually ground in a

barrel grinding machine. This machine is in effect a lathe in which the barrel is revolved slowly between centers, but instead of a cutting tool a grinding wheel running at high speed is brought against the barrel's surface; and this wheel, as it travels the length of the barrel, is guided so as to follow its taper formation exactly. Thus the barrel is brought to its finish dimensions, and comes from the grinding machine with a very smooth, bright surface. Nevertheless, the "grain" of the grinding is around the barrel, whereas it should run lengthwise, and must be polished off. On a barrel that has been ground very little striking is needed—sometimes none at all

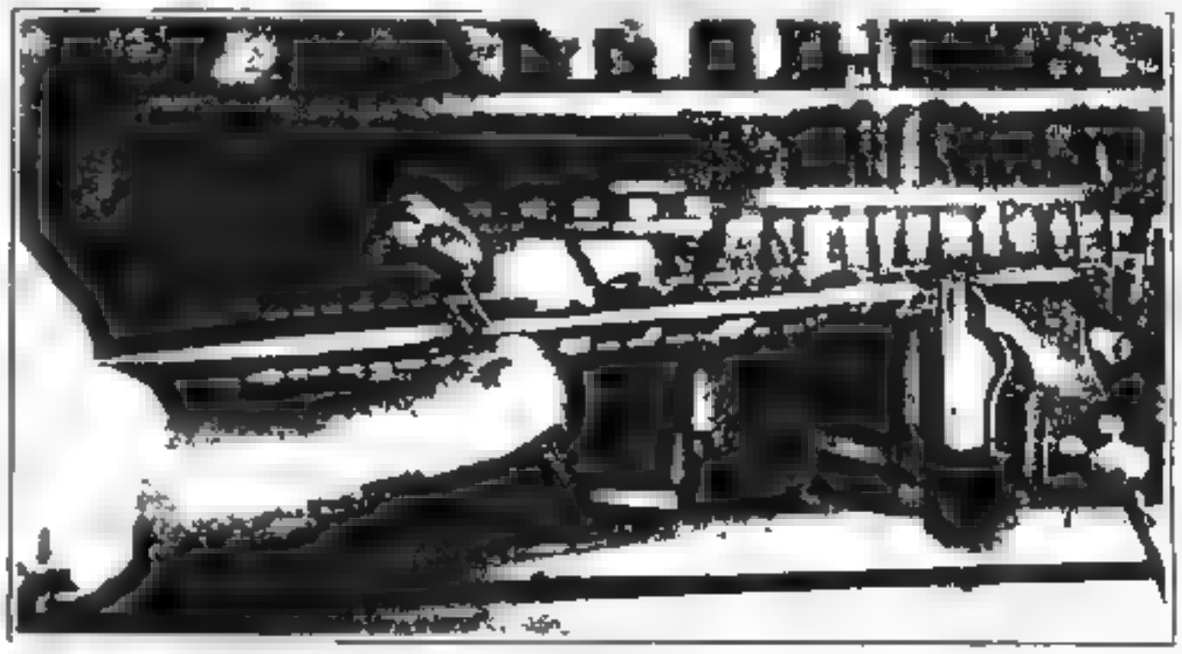

Fig 120

The principal tool needed is a large, wide, and very fine cut file. The best for the purpose is an American Swiss, a Nicholson, or a Disston "pillar file" as described in Chapter 3. This should be at least ten inches long, and at least an inch in width—the wider the better. A wide file follows the straight surface of the barrel, while a narrow one tends to cut unevenly, giving it an "ocean-wave" effect as you look down the sights.

These pillar files are available in much finer cut than ordinary machinists' files. Ordinarily the 00 cut is about right for striking, but if a particularly good job is wanted, the barrel may be struck again with a file having a 0000 cut.

Using heavily padded vise-blocks to prevent damage, hold the action in the vise with the barrel's entire length available for the work. Keep a piece of chalk handy, and chalk the cutting side of the file all over at frequent intervals. This prevents the particles of steel from the barrel from clogging the file teeth, or "pinning" as it is termed. If this occurs, deep scratches will be gouged in the barrel which will be difficult to strike out. The file card, or brush

with short, stiff, steel wire teeth, must be used to clean the file thoroughly after every few strokes, and the file rechalked after each cleaning.

Use the file in both hands as illustrated in Figure 120, and run every stroke the full length of the barrel, maintaining a constant firm pressure. It is not necessary to bear down hard enough to spring the barrel—just a firm steady pressure both ways, so that the file takes a cut "coming and going." A little practice will enable you to feel the right pressure, so that the file will just take hold. Excessive pressure will result in too deep a cut and make "flats" a sixteenth of an inch or wider along the barrel, and these are hard to work out.

Too little pressure, however, is as bad as not enough. A file's purpose is to *cut*—not to scratch. Each stroke should remove an appreciable amount of metal. Some men never acquire the knack of fine surface filing—the fear of cutting too deep causes them to merely scour and scratch the surface. It is surprising how many full pressure strokes are required to reduce a piece of stock a thousandth of an inch.

When you learn to strike a barrel with the proper pressure, neither too light nor too heavy, the cuts taken will have scarcely any appreciable width—or in other words, there will be no flats visible on the surface.

Nevertheless, the flats are there, and the next step is to polish them out. Emery cloth is the usual polishing medium, but I prefer carborundum or alundum cloth when it is obtainable, due to its

longer cutting life, and faster work. This material is sold by ma-

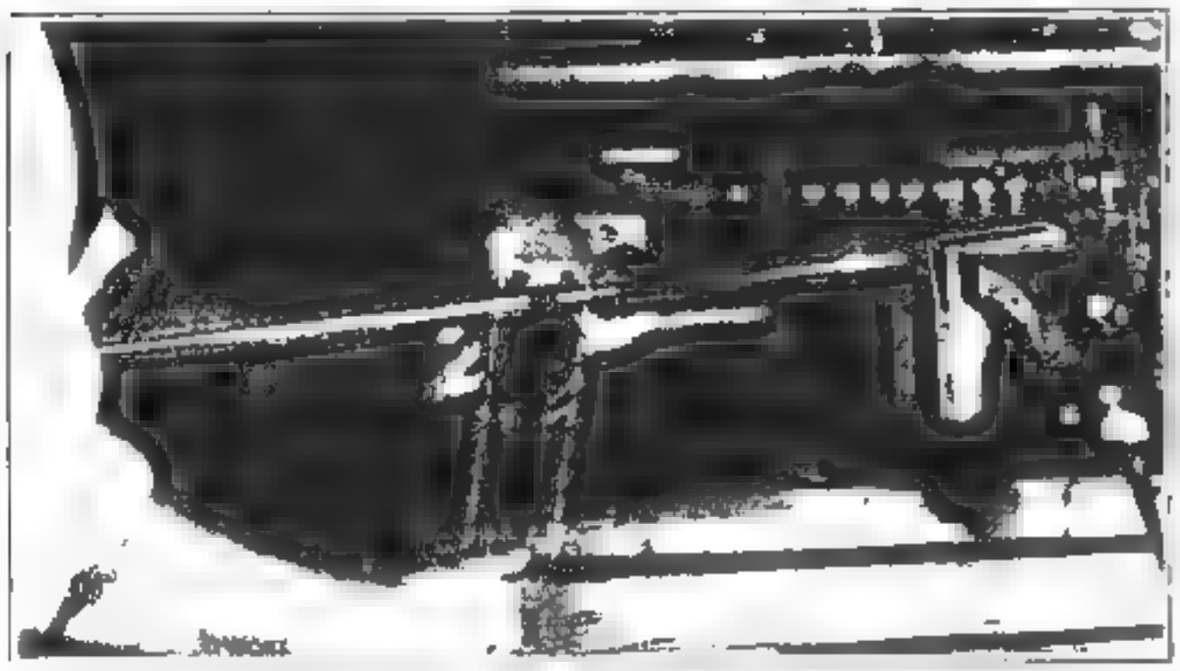

Fig. 121

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chinery supply houses in large rolls, of one, two, or three inches in width. Most firms will sell it by the yard, from the roll, and three or four yards will last a long time in the small shop. The large shop will find it economical to buy it by the roll. The size of grit needed will be 00, 0, and 1/2.

To show up the small flats left by the striking, cut a strip of 00 emery or carborundum cloth 3/4 inch wide and about a foot in length. Grasp the ends firmly in each hand and use it as shown in Figure 121—just like shining a shoe with a rag. Very gradually, move from one end of the barrel to the other, using very light pres-

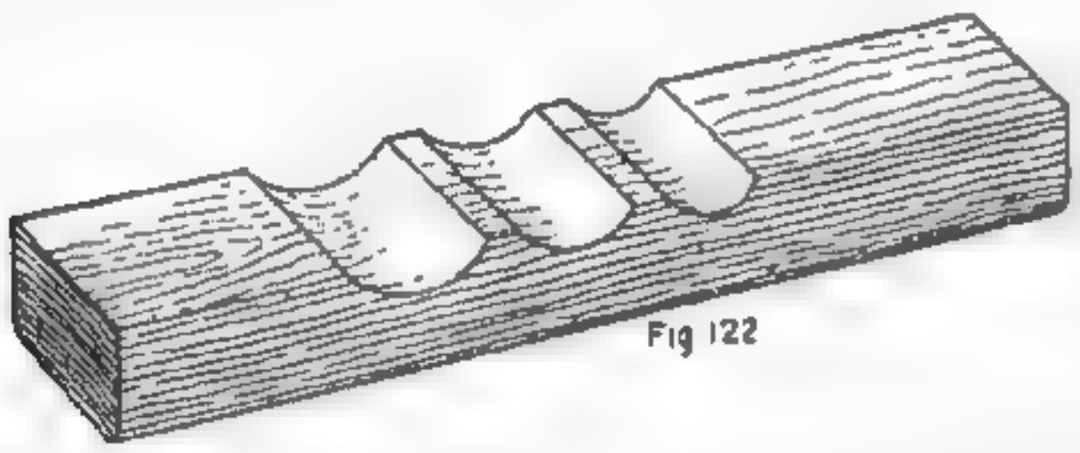

Fig 122

ure. This will cross-polish the barrel for about half its surface, then it should be turned over in the vise, and the under side polished in the same manner.

Now you can see the small flats left by the file. If they are very pronounced, they may be partly eliminated by again cross-polishing with No. 0 abrasive cloth.

And then you are ready for the "DRAW-POLISHING" which is the same as draw-filing, except that the abrasive cloth is used instead of the file.

Cut a hardwood stick ten to twelve inches long as shown in Figure 122 with semi-circular notches in two or three sizes. These may be cut by first making the stick wider than wanted and boring holes in it with the proper sized bits, after which half the stick is ripped off and discarded, or may be saved for a "spare." The working surface should be lined with a piece of thin leather—about the weight used in the upper of a shoe or a piece of thin strap. This should be firmly glued to the wood, to form a slightly resilient base for the abrasive cloth. The cloth may be shellaced to the leather, but a better way is to coat both the leather and back of cloth with thick rubber cement and let it dry for ten minutes. Then press the cloth in place and it will remain until worn to the point of uselessness, when it may be readily peeled off, and a new strip cemented in place.

The round notches in this polishing stick should be of such a size as to fit easily over the barrel after the leather and cloth are applied. They should not fit the barrel tightly, or they will make

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cross scratches as the stick is lifted at the end of the stroke. On tapered barrels you will have to use a notch big enough for the largest part, although a smaller one may be used near the muzzle, and the stick lifted gradually as the stroke approaches the thicker part of barrel.

Grasp the stick in both hands and use it just as you did the file. If it has to be stopped short of a full length stroke, lift it as you stop. Never stop with the abrasive still on the barrel, or there will be small scratches at the end of each stroke.

The first polishing with the stick may be done with No. 1/2 abrasive, using moderately light pressure at first, and increasing pressure as the abrasive wears down. When you have polished the entire surface, and the barrel has an even, silvery appearance with no flats showing, do a little cross polishing with No. 00 abrasive cloth, and you will probably find the flats still visible, although partly worked. Now cross-polish again all over, and again draw-polish with the stick; continue to alternate these operations until the flats are no longer visible, then draw-polish with No. 00 cloth on the stick, and if you want a moderately dull finish on your barrel, you have it without further work. Use the 00 cloth until it is pretty well worn away, and no finer abrasive will be needed.

When a very BRIGHT FINISH is desired—and particularly on pistols and revolvers, as well as parts that are to be niter-blued, the polishing should be continued as follows:

Fold a quarter sheet of 00 emery cloth twice, making a pad about two inches square, and partly wear out the surface on a piece of scrap steel or an old barrel. Then squirt a few drops of thin oil (any gun oil) on this partly worn surface, and holding the cloth in the palm of hand, scour the barrel with full length strokes until the emery no longer cuts. Carefully wipe barrel dry of all oil, and polish again in the same manner, using crocus cloth. The crocus will produce a very high polish, but works slowly; and the polish it produces will likely show a few streaks and imperfections, due to incomplete polishing with emery. If so, they must be completely worked out with the oiled emery cloth, and the crocus polishing then resumed. Finally the barrel may be buffed on a thick, six inch cloth buffing wheel, to which a very little polishing rouge may be applied.

When a barrel has been polished with oil, or buffed, the pores are so filled that it cannot be successfully blued by any method until thoroughly cleaned. Make up a hot solution of strong soap and sal soda, dip into this a clean rag, sprinkle on it a small amount of powdered pumice, and scour the barrel thoroughly; rinse in clean boiling water, and if the water puddles off showing a greasy surface, scrub and rinse again. Then flush it off thoroughly with Pickling Solution No. 4, (See Chapter 20) again rinse in boiling water several times, and dry with a clean cloth. This treatment is merely to remove foreign matter from the pores of the metal, and the regular

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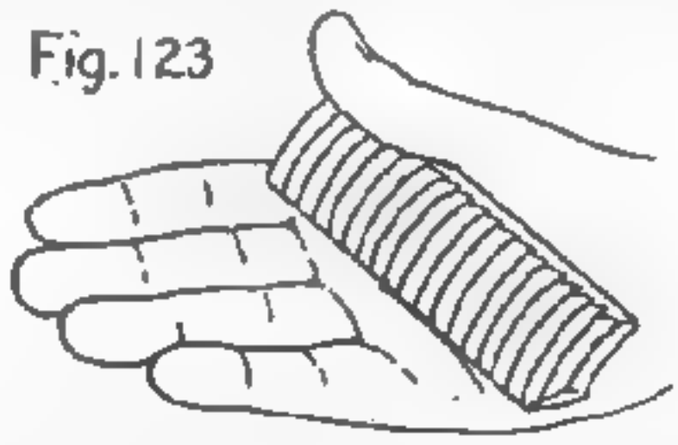
boiling in lye prior to the bluing must still be done as explained later.

WORKING DOWN BARRELS: The barrel of our Springfield service and national match rifle is rough turned almost its entire length, having only four or five inches at the muzzle smoothed down, since the remainder is hidden by the forend, hand-guard and rear sight base. When this or any other rifle having a very rough barrel is converted into a sporter, it should, if possible have the barrel removed from the action, turned down smooth in a lathe, and ground. This being beyond the reach of the amateur remodeler, however, the following method is nearly if not quite as effective.



In one sense it is better, since it involves no danger of some machinist turning the barrel down too small, or perhaps springing it in the turning process.

Secure a "Vixen" file, which has very large, deep single teeth cut on a curve. This file will be an inch, or an inch and a quarter wide—the wider the better. Set it in a vise and break it up into pieces two to three inches in length and grind the broken ends smooth on an emery wheel. Clamp the rifle action in the vise

leaving the entire barrel available for working. Hold a short piece of the file in right hand as shown in Figure 123, planing off the barrel evenly and removing all high spots. Do not take too deep a cut, and work completely round the barrel, until all the rings made by the turning tool are planed off. The short length of file, laid lengthwise of the barrel avoids the danger of making a wavy surface, as you would be almost certain to do otherwise. The Vixen file cuts very rapidly and of course forms larger flats than would a finer file. To remove them, strike or drawfile the barrel first with a wide mill file (one inch or wider); then cross polish vigorously with No. 1/2 carborundum cloth to show up the flats; next draw-polish with folded emery or carborundum cloth on palm of hand; again cross-polish lightly with No. 0 cloth, then strike and polish as already explained, starting with the large pillar file.

POLISHING PROBLEMS: The foregoing includes all essential principles of barrel polishing, and should enable one to handle

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any job without difficulty. A little ingenuity is of value here, as elsewhere in the field of gun work. Each job presents its own problems, the most common difficulty being that of getting at inaccessible places, such as around sight bases, etc. A good rule to follow is always to remove everything that is removable, and polish first the barrel, then the sights, bases, etc., and put them back on. Then any pins used in attaching can be polished off with a minimum of labor and difficulty. One exception to this rule is the fixed stud

PLANING DOWN A BARREL WITH A PIECE OF VIXEN FILE

on the Springfield barrel which need not be removed. The stud should first be polished without regard to the barrel. Then the polishing cloth and files may be worked right up against edges of barrel band without damage to its finish. When bands for swivels or forend screws, or bands forming leaf sight bases are used, they should be fully polished *in the direction of the barrel's length*, before being fitted into place. Polish the barrel, fit on the polished bands, or sight bases, then a light final polishing of the entire assembly will not be difficult.

Barrels and parts should also be fully polished before soldering on any bands, sight ramps, etc. The heat of soldering will of course blacken and discolor the metal at this point, but the surface being quite smooth, only a little final polishing is needed.

Both care and patience are necessary when polishing around parts that have been soldered on. If the least bit of solder remains in the edges of a barrel-band or ramp, it will not blue, but will "grin" through the final finish and mar the appearance of the whole arm. The solder, being practically the same color as the bright steel is

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often unnoticed until the bluing is well under way. When this occurs, the best course is to step outside where there's plenty of room, cuss until you feel properly relieved, then scrape off the solder, repolish the barrel, and resume operations. Kicking the cat, providing you have a cat, will also help materially.

I keep an old hacksaw blade—or rather a short piece of blade—with the end ground to a long point and sharpened on both edges. This forms an excellent scraper for getting into the edges of a barrel band or ramp and removing the solder. It must be remembered that in the "sweating" process the solder actually penetrates the surface of the steel, though perhaps not more than half a thousandth in depth. Nevertheless, wherever excess solder shows on the outside after a sweated job, a good bite must be taken to assure its complete removal. A light etch with a 1-to-7 Nitric acid solution at this point will usually assure complete removal, and the surface so etched may then be polished to match the rest of the job.

Double shotgun barrels and ribbed rifle barrels are of course slower and more difficult to polish than plain round single barrels. Shape small pieces of hardwood to fit into the various corners and crevices, and glue your abrasive cloth on these. Nothing looks worse on a finished barrel than a streak showing where the polishing failed to get into the corners.

The rear end of a rifle barrel where it abuts the receiver, is another hard place to get at. A strip of abrasive cloth folded around a hacksaw blade will get you up about as close as anything I know of.

Where an extreme matte finish is desired on a barrel, this may be easily produced after the barrel has been smoothly polished with abrasive, by buffing on a rather stiff iron or steel wire buffing wheel. The buffer should run at least 2000 R.P.M., and preferably 3000. Hold the barrel with light pressure against the buffer. At first the wire will merely burnish the barrel to a rather bright finish. Now increase the pressure gradually, until you feel it "take hold" and you will notice this pressure has given the barrel a dull, silvery, and somewhat "grainy" appearance. By maintaining just this required pressure while moving barrel about on the wheel this matte finish may be imparted to its entire surface evenly, although considerable practice is needed before one can do a good job.

Most actions present greater difficulties than barrels, by reason of the various curves, angles and inside cuts, which are difficult to reach. Practically all polishing must be done by hand, with abrasive cloth folded into convenient shapes. Flat surfaces on lever and pump action receivers can often be struck or draw-filed to advantage, with the same files used for striking barrels. Inside curves and hollows, such as the inside of trigger guard, can best be reached with a very fine oval section file, and when polishing these places, the abrasive can be wrapped around this same file, or around small pieces of wood shaped to fit.

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Regardless of the difficulties a job of polishing presents, remember it was polished at the factory when made, so your work is no harder than that of the man who made the gun. By studying the surface carefully you can usually see in what direction the original polishing was done, which gives you your cue.

The same applies to automatic pistols and revolvers, both of which offer some mighty mean polishing problems. The polishing is usually done in the direction of the milling cuts which formed the shape. The main thing is to avoid all scratches or cross marks, which will appear as glaring defects after the gun is blued.

BUFFING may well be resorted to on any pistol or revolver job. The best wheels for this purpose are the hard, solid felt ones which may be purchased in a variety of sizes. Use Tripoli or other standard brand of rouge. If you have a high speed grinder with

Fig 124

tapered spindles on each end, it will pay also to turn up some small pieces of hardwood like Figure 124; these are bored at one end to screw on end of grinder spindle, and the other end covered with felt, to which rouge is applied. These spindle buffers are worth their weight in gold for working inside the trigger guard, and in narrow and shallow outside curves.

On military arms with hardened receivers, you will find emery of little value for polishing. It cuts slowly, and breaks down very quickly. Carborundum or alundum cloth is much better, and due to the hardness of the metal, a coarser grade may be used without danger of cutting too deeply. Thus, where you would use No. 0 on a barrel or other soft parts, you can use No. 1/2 or even No. 1 abrasive on hardened receivers. A finer grade should of course be used for finishing, followed by buffing on a muslin buffer with plenty of rouge to remove any cross marks that show. There is no need to polish the bottom side of receivers where they are hidden within the stock. This is a waste of time and necessary only as a matter of principle on high priced jobs.

POLISHING BOLTS is not difficult, although one's ingenuity is often taxed to devise ways of holding them in the vise. The Springfield bolt from a service rifle is Parkerized, hence quite rough and hard working. The extractor and extractor collar should be removed, and with one end of bolt held firmly in vise, the bolt should be cross-polished with No. 0 Carborundum cloth until all old finish is off. Along the sides of the safety lug and locking lugs cross-polishing will not get to the surface—here you must have recourse to a small piece of cloth folded to reach into the corners. After cross polishing, the bolt should be draw-polished lengthwise

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with a piece of oiled emery cloth, folded as required, making the surface as smooth as possible. It should then be worked in the action with fine abrasive until it works very smoothly, as described under "hard fitting" in Chapter 25.

The mottled effect or "chasing" seen on bolts of many high grade arms is easily produced as follows: Cut off a small piece of hard rubber or fibre rod about 2 inches long, and 1/4 inch diameter Round one end *very* slightly and chuck it in a drill press or lathe. Mix a little very fine emery flour with heavy oil or grease (or use a little valve grinding compound) and apply this to the rounded end of the rod. The drill press or lathe should be run at fairly good speed, and the bolt brought against the end of the fibre rod. Move the bolt slowly from end to end, pausing momentarily at intervals of a quarter inch or so, until the whole surface has been chased. Very little abrasive is needed for this, as you want to merely mark the surface—not cut it deeply.

One objection to such a finish, attractive though it may be, is that it will reflect a ray of sunlight for a long distance—a bad thing for any hunting arm to do. However, this chased surface may be blued, which in no way detracts from its appearance.

If you have no drill press or lathe, you can get the same results by setting the fibre rod in a breast drill which is held in any convenient position in the vise; have an assistant turn the drill rapidly, while you guide the bolt.

SMALL PARTS, such as triggers, etc., are often best polished by cross-polishing with a very narrow strip of abrasive cloth. Be sure they are held firmly in a vise, and in such a manner as not to mar, bend or otherwise damage them. This matter of holding parts during the polishing is one that must not be overlooked. Even a 45 Colt automatic slide can be so badly sprung that the arm will nor function, with just a trifle too much pressure in the vise. Yet parts must be held firmly—rigidly—or they will slip and be badly marred. Shotgun receivers are often milled quite thin, and are easily bent. Where any considerable outside pressure is needed to hold parts, pieces of hardwood, scrap steel stock, old barrels, short pieces of heavy tubing, or other suitable material should be fitted inside to take the strain.

Protecting the parts from damage by the jaws of the vise is equally important. The maddest man in the world is the fellow who has spent an hour polishing a receiver, then ruined it by squeezing in the rough checked jaws of a vise. Sheet brass, copper and lead should be on hand always, and the vise jaws covered with the material that proves most suitable. Scraps of heavy leather, such as saddle skirting, are also valuable. When the work is inclined to slip against a leather protective piece, the surface of the leather may be dusted with finely powdered rosin, which will make it take hold firmly.

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Small flat surfaced parts, such as hammers, must be polished in such a manner as will not alter their flat surfaces. The best way to do this is to hold the part in the hand and rub it back and forth on a piece of fine abrasive cloth stretched over a flat surface—a flat bar of steel, a file, strip of plate glass, or a new oilstone. For the final bright finish the abrasive cloth should be oiled, then the part may be buffed lightly with a little rouge. Most inside mechanism parts must be brought to a fit as the polishing proceeds, and this is covered in Chapter 25, under "hard fitting." After polishing, inside parts may be chased in the manner described for bolts.

Referring once more to the frequent difficulty of holding parts while polishing, I often find it advisable, for parts having a small hole for a pin or screw, to drill and tap a hole in a piece of scrap steel or brass and attach the part firmly to it with a suitable machine screw. The scrap piece can then be set up tight in the vise, or may be used as a handle while buffing the part. Very small screw heads present a difficulty that is easily overcome. In guns that have been used for any length of time, the screwheads are usually damaged by someone's misguided efforts to remove them. The heads may be smoothed up and their shape restored with a fine file, and the slot trued up either with a slitting file or a piece of hacksaw blade with the "set" ground off the sides. Holding the screw during these operations presents the difficulty. Take a piece of brass or copper about 1/8 inch thick, and drill and tap it for the screw. Turn the screw in firmly but not too tightly, and hold the scrap in the vise. This is a good way to hold any screw while working on it, but larger screws often fit the threads so loosely that they turn as you work on them. This can be prevented by cutting a slot with a hacksaw from the end of the scrap piece into the screw hole. This permits the vise to force the edges together and grip the screw firmly, without the least possibility of damaging the threads. This kink is good also where a screw shank has to be cut off very short. Turn it into a piece of brass the required distance, and grind off the end on the emery wheel—the threads will be perfect to the extreme end.

After the parts are polished, unless they are to be blued immediately, they should be protected from rust by wrapping in waxed paper and kept in a dry place. Coating them with grease is not advisable unless they must be kept for some time, as it merely increases the work of cleaning when the time comes to blue them.

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CHAPTER 19

ENGRAVING AND ORNAMENTATION OF METAL PARTS

WHEN this book was first drafted the question of giving instructions for elementary engraving was discussed and its possibilities thoroughly investigated. After talking to a good many engravers it was decided that any attempt at engraving by the amateur or anyone not fully apprenticed in this art, would surely result disastrously. Jewelry engraving on soft metals requires several years of close application before it can be mastered, yet few jewelry engravers will attempt even the simplest job on a gun. There are few really good gun engravers in America, and these have reached a high state of perfection in their art. The man who desires engraving on barrel, receiver, guard or floor plate must make up his mind to pay the price for good work, or else do without it. In no instance should a high grade gun be entrusted to one not thoroughly familiar with the cutting of deep designs on hard, tough steel, nor one who has not a well developed sense of the artistic, as well as the mechanical ability.

Among leading engravers of fine guns may be mentioned Mr. Rudolph J. Kornbrath, of Hartford, Connecticut. Mr. Kornbrath's work is of the highest character, and quality considered, it is reasonably priced.

There is no reason why the home gunsmith may not have his gun as beautifully engraved as the finest de luxe jobs of the best makers. The barrel and action should be well polished, and sent to the engraver "in the white." Do not try to tell the engraver how to do his work—and don't tie him up with a lot of specifications that will hamper him in the exercise of his talent. If possible, send him a picture of a gun that is engraved about the way you want yours, and he will give you an estimate of the cost. Or, decide about how much money you want to spend on this decoration,

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and tell him to give you what he can for the price.. Initials, monograms, birds, game heads, etc., can be worked out in gold, silver or platinum inlays which combined with the engraving on the steel give very beautiful effects. All these details must be taken up with the engraver himself, and you will find him ready with many helpful suggestions.

The cost of engraving may run from ten or fifteen and up to several hundred dollars. Often a simple border line or two cut around the breech and receiver, on floor plate and guard, will relieve the plainness and add many times their cost to the appearance of the arm. Do not rush the engraver—he usually has work for weeks ahead, and his kind of work cannot be hurried. Give him all the time he wants, and trust him to give you value received.

THE DANGER FROM ENGRAVING: Before you decide

to have your high power rifle engraved, remember that the receiver must be annealed before the engraver can cut it. Be sure your engraver is reliable, understands his business, and has the facilities for properly hardening and heat-treating the parts after engraving. I have seen Springfield and Mauser receivers come into a shop and be blued and finished and delivered to the unsuspecting purchaser, with no pretense at heat-treatment or even case-hardening. Every gun-crank knows what that means, with modern high pressures.

When having barrel fitted to an action the receiver must be annealed, engraved and rehardened before the barrel can be fitted. Then the engraving on barrel must be done later—this means two trips to the engraver's. I believe Niedner is prepared to do a very good job of receiver hardening, and were I having a special barrel from him, would have the engraved receiver sent to him for hardening before the barrel was fitted. Mr. Kornbrath advises that he is also in a position to have receivers properly hardened after engraving, and in view of the fine work he turns out for leading manufacturers, I would not hesitate to entrust this work to him. Under no circumstances, however, should this work be entrusted to some unknown person of doubtful ability, who may do a poor job that will endanger the weapon itself and the life of its owner. A good, safe rifle should be the first consideration; beauty of finish comes afterward.

There are some gunsmiths, barrel makers and others whose bump of self esteem is highly over-developed. They will "yes" you to the limit on any question of design, construction, or finish. They know it all. Every now and then one of their jobs let loose, maiming or injuring the shooter for life. The least harmful things they do is to ruin a gun which you may prize highly, and on which you have spent considerable money. I am reminded of the time I watched the efforts of a man who stood high in his field, remodeling the bolt handle of a Mannlicher-Schoennauer. The owner didn't like the flat handle, nor did he approve its location. He wanted it length-

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ened and bent back closer to the trigger, and provided with a knob shaped like that on the 54 Winchester. Yes, the gunmaker could give him what he wanted—in fact anything he wanted. And he should have been able to do so in this instance. The bolt handle was bent to position and fitted with a knob slightly smaller than a bantam's egg. Naturally the customer refused it, and returned the gun. On the second attempt, instead of wrapping the bolt in wet rags thus protecting it from the heat, the entire bolt was allowed to become red hot. This bothered the famous gunmaker not one bit—he would re-harden it. He did so—by heating it nearly to white heat in cyanide and dropping it into cold salt water. It came from the water in two parts—and there was not a spare Mannlicher bolt in the United States at that time. Another time I saw an attempt to harden a Springfield receiver in cyanide—the owner was a great admirer of color hardening, and the gun maker was in an obliging mood. The result was a cracked receiver—which was a mighty good thing because it taught the owner a lesson.

GRINDING DOWN RECEIVERS: I have observed that at least two shops do not hesitate to grind off the serial number and name of the armory on top of the barrel ring of the Springfield receiver. Personally I have never considered that the stamp of United States government manufacture is any disgrace on a rifle, or detracts in any way from its quality or its beauty. I cannot make myself believe that grinding off a sixteenth of an inch of steel at this point adds anything to the receiver's strength. I have noticed that some of the best imported rifles have the matting right over and around the lettering on the barrel ring, and the effect is not at all unpleasing. One knows who is responsible for the gun he is shooting, and he knows the receiver still has the same dimensions specified by its designer. While the gunmaker who has spent his life hunting the wild wahoo in the fastness of Abyssinian forests and pulling the teeth from old tough drunken republican he-elephants all over the dark continent *may think* he can grind away half of a rifle and still have it safe to shoot, I'm going to take the word of the folks who designed and built the gun in the first place. I may be a fatalist—at times—but I'm careful all the time.

AMATEUR DECORATION: The only decoration that should be attempted by the amateur—and by most professional gunsmiths also—is that of matting the top surface of sight ramp, rib, or top of receiver if it is not too hard. There are several easy ways to do this. One method I have found very successful on ramps and other soft steel parts is as follows:

Get a big rattail file—the bigger and coarser the better. I have one 14 inches long and 3/4 inch diameter which turns out a good job. After the sloping part of ramp is worked down to size on the barrel, the barrel is set horizontally in the vise. Now lay the big file across edge of ramp and with a hand on each end of file push

[redacted]

it up and down the ramp—just like rolling out biscuits with a rolling pin. The file teeth pressing into the surface of the steel make a good impression if you bear down well. Change the angle of the rolling from time to time so as not to leave an exact imprint of the tooth pattern. About five minutes of this will give you a good matted surface—not very deep, but plenty deep enough. Now bevel the edges slightly with a sharp file, to leave a clean smooth line about 1/32 inch wide.

Another way is to make a multiple stippling punch, or use a wood carver's marker, which is the same thing, and hold it above the surface to be matted, lightly tapping it with a small hammer, while moving it about over the surface. The impression of the points will quickly cover the surface, making a very attractive job. A small sharp prick punch makes an even more attractive surface, but the single point slows up the job to a half hour or more. Hold the point of punch just above the surface, and keep up a light tapping with the hammer or piece of hard wood, constantly moving the punch about. The edge may be slightly beveled if desired, to give a good finish.

The workman who is provided with the dental engine described and illustrated in Chapter 4 is as well equipped for matting as he can ever hope to be—this device is the peer of them all. In addition to having rotary motion in the head for small grinding wheels, it may be adjusted to give a hammer motion at the point—similar to the big pneumatic riveters—and striking hundreds of blows per minute. With a small sharp punch in the head the device may be used like a pen or pencil, and the finest sort of matting job done in a very few minutes. Keep moving the point rapidly over the surface until no bare spots remain—the machine does its own hammering as it goes. The matting thus produced is even better than the prick punch method—deeper and more even, so that it fairly glistens. It is so sharp that it may be advisable to smooth the surface slightly with fine emery cloth before bluing.

Using a very sharp well hardened punch in this tool, one may mat the top of a Springfield receiver if not extremely hard. It may be necessary to grind and harden the point several times, but this device will do the work. Most other receivers may be matted without difficulty or damage to the point.

Now for the last and easiest way of all. If you are located in the city and have electric lights you will need a 6 volt transformer costing $3.50; if out in the sticks, get half a dozen dry cell batteries, or use the battery in the family flivver. What you're after is six volts at 75 amperes—makes no difference how you get it, so you do it honestly. The Ark-O-Graph pen is a little gadget about the size of a fountain pen, with a piece of copper wire for a point. A wire from this connects with one side of the transformer. A wire from the other side is grounded anywhere on the metal of the gun.

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The instant the point is touched to the surface of the steel a tiny arc is formed—sparks fly—and there's a dot on the surface, burned in with the heat of the arc. The Ark-O-Graph doesn't know the difference between hard and soft steels. You can write your name on files or other hard tools with it, and by moving the point rapidly over any metal surface it is matted quickly and without fuss. The dots are not so deep as they might be, but they're there to stay—burned right into the steel. The D. C. M. Sporters now come from the armory with the serial number written on the bolt—with an Ark-O-Graph. The device is sold direct from the factory, Ark-O-Graph Pen Company, 1171 E. Stark St., Portland, Ore., and costs $3.50.

I wish somebody would bring out an Ark-O-Graph with a hot enough spark to do very small electric welding—what a handy thing it would be on sight work, for welding ramps to barrels, etc., etc., etc. And I wish somebody would rig up an electric pyrographic needle, with a coil inside that would heat the point white-hot. When not dolling up stocks for the fellow who hasn't much money to spend, I'd use it for brazing, maybe. At least I'd try it.

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CHAPTER 20

BLUING, BROWNING, AND COLORING METALS

THE bluing or browning process is one of the most intriguing subjects in the realm of gunsmithing, either amateur or professional. It is a subject on which the large arms companies have spent many thousands of dollars. Moreover, it is a subject that many otherwise excellent gunsmiths have never fully mastered, while others have become highly proficient. Both the factories and the gunsmiths, having found one method giving fairly satisfactory results, usually settle down to that method, and refuse to attempt any other.

This is not the ideal attitude to take, however, by any means; for experience has taught that certain parts of an arm are best finished by one method, others by a different process. Moreover, different steels react differently to treatment, so that a process perfectly adapted to one barrel or receiver, may not be so successful on another.

Some shooters have the belief, largely erroneous, that bluing or browning is intended and serves as a protection against rust. The fact is, that most finishes are themselves the result of rust or oxidation in one form or another, and offer very little protection against further rust. The only finish that affords rust protection is a plating with a non-rusting metal—of which more will be said later.

The real purpose of bluing or browning is to impart to the gun a dark color which will not glitter in the sun, and at the same time give it the appearance which we have come to associate with guns through long usage.

The old time gunsmith back in the woods "browned" his barrels by rusting them with a solution of aqua fortis, cider vinegar, or what have you. His barrels were of soft iron, and of course the original finish quickly wore off; but hard usage in all kinds of weather, with

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perhaps not too much care as to condition of the finish, kept the outside always somewhat rusted, while the wear of handling kept the rust off, but left a dark brown color that answered the purpose.

When a factory settles on some one method of finishing, they get busy and develop that finish to a high degree. Often the finishing is in charge of one workman, who, likely as not, keeps the process largely to himself in order to have things his own way. Then if he dies, or is proselyted by a competitive organization, it is necessary to do a lot of experimental work involving considerable cost to develop a new and satisfactory finish or even to keep the old one up to standard.

It is remarkable how "set in their ways" some gunsmiths get to be—especially in the matter of bluing and browning. There is an old timer in my town who cannot be persuaded to tackle a bluing job in summer; but take him the gun in winter and he'll "do it up brown"—literally. He uses an oldtime cold rusting process (which he guards most jealously,) and he doesn't have good luck with it in warm weather—or thinks he doesn't. Probably he is able to maintain a more uniform humidity when using artificial heat. Anyhow, he is superstitiously afraid to change his process, which he maintains is the only one in existence worth a hoot.

Bluing and browning methods may be classified under four general heads, as (1) Chemical solutions, either hot or cold, which cause surface oxidation and consequent coloration; (2) Chemical solutions which change the surface of the iron or steel into a different substance; (3) Heat, or combination heat and chemical processes causing surface oxidation and coloration; and (4) Plating.

Numbers 1 and 3, being of greatest interest to the trade, will receive most attention in this chapter. It will be necessary, however, to mention another process that belongs in the second class mentioned, namely, Parkerizing. Springfield service rifles are now finished by this method, which is highly rust resisting, and which is also used on typewriters, adding machines, telephones, outdoor hardware, ornamental ironwork, and many other items.

Parkerizing, briefly described, consists of boiling the parts to be finished in a solution of "Parko Powder," composed of specially prepared powdered iron and phosphoric acid. In the process, minute particles of the gun or other object being treated, are dissolved from the surface and replaced by insoluble phosphates which are rust-proof. This results in a slight etching of the surface, giving a dull, non-reflection finish, which, while less attractive than bluing is far more practical from a military standpoint. It is possible, moreover, by afterward buffing the surface with various oils, to produce a soft gloss that is quite attractive. With a little further development it seems that some arms factory might bring Parkerizing up to the standard of appearance demanded by shooters, and the rust-proof qualities of such a finish would be highly desirable.

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Parkerizing is a patented process; the materials are sold by the Parker Rust Proof Company, Detroit, Michigan, to licensees who are required to pay a very nominal sum for the right to use it. A somewhat similar process involving the use of a commercial product known as Hydrogen Acid R & H No. 1, and powdered iron is offered by the Roessler & Hasslacher Chemical Company, New York City. The treatment of parts being finished is about the same as in Parkerizing. Both of these processes will require from one-half to three hours, according to size of the work, and both are one-operation processes.

Plating, in my opinion, offers possibilities that the firearms industry might develop with advantage to itself. While the nickel plated "bull-dog" revolver does not enjoy its old time popularity even among the town boys who bought their guns from the mail order house, yet modern electro-plating would be well worth while on many guns. "Black Nickel" is something that only a few master platers know anything about; nevertheless, I recently inspected a fancy Browning automatic shotgun that I would swear was black nickel plated from stem to stern; the color is distinctive—a rich, deep brown-black—and can scarcely be mistaken by one who has ever seen it. And it is absolutely and permanently *rust proof*. The danger to its permanence lies in the fact that some platers have never learned to make nickel "stay put" on steel; unless done right, it will eventually peel off like tinfoil. The best practice is to first plate the job with copper, then the nickel, deposited over the copper, will seldom if ever come off. Nickel has but slight affinity for steel; but its affinity for copper is high.

I have had small pocket guns, derringers, etc., plated with copper which was then treated with an ammonia solution to oxidize the copper and turn it black. The color is not particularly good, however, although the gun will not rust in a sweaty pocket, which was the end sought. I even knew a chap who, noting the tarnishing effect of his morning egg on the family silverware, went so far as to have his gun silver plated, then oxidized it with the contents of an egg previously prepared by letting it stand in the sun for a few days! And it was a pretty fair job of bluing at that—and rust proof.

In Amateur Gunsmithing, Colonel Whelen suggests a practical method of using the oxidized copper method, briefly described as follows: "With the bore of barrel tightly plugged, and outer surfaces cleaned, support the barrel in a horizontal position, and splash on a solution of 1 dram blue vitriol (copper sulphate) in 12 ounces distilled water. Apply the solution with clean soft bristle brush, or mop of clean cotton cloth. A coating of copper will be deposited on the barrel. Then, in the same manner, apply a solution of ammonium disulphide, which turns the copper coating black. Flush off with clean warm water, and dry lightly with clean rags."

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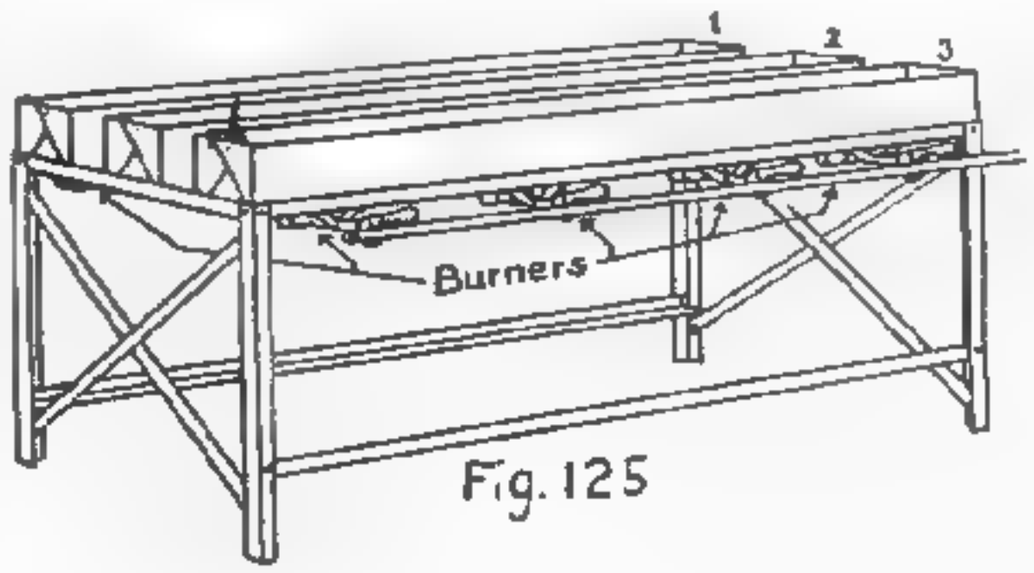

Fig. 125

The method described is good for a quick temporary treatment; but the coating produced is very thin, and does not wear well; moreover, oil is somewhat destructive to it, which makes it a poor finish for a gun.

Further consideration of plating methods need not be considered here. The plater has and requires equipment not needed by the gunsmith, and costing more than most shops would be justified in investing. If any plating method is selected, it will be found desirable to arrange with a first class plater to do the work on contract, and to allow him to use his own processes with which he is familiar.

BLUING EQUIPMENT: Before going into the solution and heat methods of bluing and browning, we must give a thought to the equipment needed. Fortunately it is simple and inexpensive, yet some equipment is necessary regardless of the process employed.

The first requisite is a sheet iron tank at least 40 inches long, 5 inches wide, by 6 inches deep. 42 or even 44 inches will be a better length—you can't tell when you're going to want to reblue a long barrel and action, and a tank a little too long is better than one a little too short! This tank is essential whether you use a cold rusting or a hot solution process, for you must be able to boil the barrel and make it chemically clean—absolutely free from any suggestion of grease.

Provide a three burner, or better still, a four burner gas plate or heater; shops located where fuel gas is not available can use a good oil or gasoline cook stove or plate to advantage; better yet, the Coleman Lamp Company, the Sunshine Lamp Company, the American Gas Machine Company, and others, supply gasoline-gas burners separately on order. These may be bought at small cost and three or four of them fitted in line into a light frame of angle iron riveted or spot welded together. The fuel supply is kept outside the building, in a 3 or 5-gallon tank with hand pump for pressure, and is carried into the shop through a hollow copper tubing.

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Shops doing much bluing will find it desirable to arrange two sets of burners, and at least two tanks—one for use with a strong alkali cleaning solution, and one containing clean water for rinsing. If a hot solution is to be used for bluing, a third tank may well be added, standing in between the two sets of burners. In use, the barrel and action is first boiled in the alkali cleaning solution; then immediately dropped into clean warm water to remove the alkali; then into the third tank, in which the water is boiling and the solution ready for use, as described later. See Figure 125.

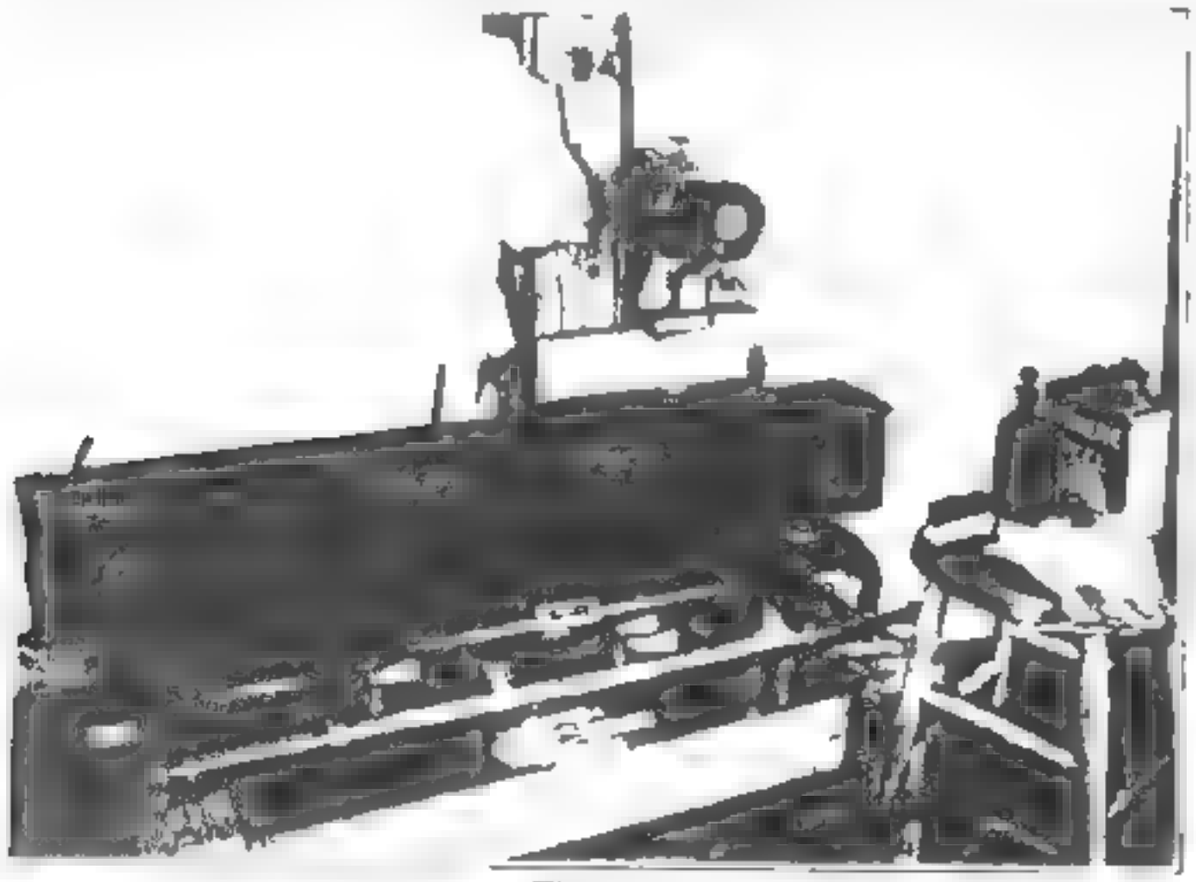

Fig. 126

But, for the man with a home workshop, or the small gunsmith doing only a few bluing jobs per year, a single tank will answer nicely. Figure 126 shows a simple and inexpensive outfit within reach of any crank. The tank should be of heavy black iron—not tin or galvanized—and any tin or sheet metal works will make a good one at small cost. Or, make it yourself by folding back the corners of a piece of metal, and putting a rivet near the top edge. The other essentials are: a can or two of household lye, a quantity of fine steel wool; several pairs of white *cotton* gloves; a few clean rags of *cotton or linen;* a small scrubbing brush with long handle; some powdered pumice stone; small iron wire bristled scratch brush; and every one of these items may be purchased at the five-and-ten-cent store except the rags, which you will probably steal, if you're onto your job.

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Before starting the job be sure your rags and cotton gloves have been through the wash, and never touch the work unless you have the gloves on. They are more important to you than rubber gloves to the surgeon! Also, wear a clean cotton shirt and apron, and keep your shirt sleeves rolled down. One touch of the work on woolen cloth or the bare skin, and you can stop the job and begin over again!

CLEANING THE WORK: Assuming you are preparing to blue a Springfield, Krag, Russian, or other rifle barrel and action; the action will be *completely* dismounted, all parts polished as described in chapter under Polishing, and grease removed by scrubbing with gasoline, then dried. Coat the inside of bore *lightly* with a heavy gun grease—just a thin coat. Make plugs for both ends of the barrel from soft white pine boiled in lye water; or cut the plugs from birch dowel rods, which should also be boiled and thoroughly dried. Leave them long enough to use in handling the barrel, and drive them in snugly, but not too tightly. Sometimes the muzzle plug swells and sticks and breaks off short, requiring considerable blasphemy to get it out.

Fill the tank two-thirds full of water (hard or soft—makes no difference), and bring to a boil; then add about 1 heaping tablespoon of lye to each gallon of water. When dissolved (and not before) put the barrel and all the loose parts into the solution. A couple of pieces of heavy iron wire may be bent into U-shape, with hooks on ends and suspended inside the tank; the barrel will rest on these instead of on the bottom, making it easy to lift it out with wire hooks.

Boil all parts from five to fifteen minutes, or until there is not a trace of grease on them. Lift up one end of the barrel occasionally and note if the surface remains wet, or if the water puddles off. This is the true test of whether or not it is grease-free. So long as the water puddles up and runs off the surface, it is greasy and will not blue by any treatment. If it seems impossible to get it clean, lift it out and quickly scour it from one end to another with a wet rag dipped into powdered pumice. A solution of strong soapsuds along with it may help also. Throw a little more lye into the tank, put the barrel back, and boil again. In lifting it out to test, don't keep it out of the water more than a second or two, or it will start to rust in spots and streaks. Just lift it quickly and see if it's wet or dry. If there is grease present, the water runs off instantly.

A long handled scrubbing brush may be used to scrub the parts lightly while in the tank, hastening the removal of the grease. If you failed to remove all surplus grease with gasoline, and much forms on the water, a second cleaning may be necessary.

The whole success or failure of the job depends on this first cleaning, so do it right. Nothing short of absolute chemical cleanliness will answer.

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When you are sure the barrel and all small parts are clean, boil them for a moment in clean water only, then rinse thoroughly in a second warm water, and you are ready to proceed with the bluing.

Use great care when removing the parts from the lye solution. As they dry they will rust almost instantly—a yellowish rust which causes spots that the bluing will not hide. This is why a second tank is desirable—you can get them right out of the lye into the hot rinse water before this rust can occur.

If using a hot bluing solution, proceed with the work at once, without drying the parts. If using a cold rusting process, dry them carefully and quickly with absolutely clean cotton cloths that have been washed and boiled. Otherwise, rust may start while cooling and spoil the job.

HOT BLUING SOLUTIONS: A solution which, when applied to a warmed or heated barrel, will produce the desired color within an hour is not difficult to prepare, nor are such solutions new to the gunmaker's trade. Some English gunsmiths have used such solutions for years, and several formulas are known in this country. The Hoffman Arms Company used one of these solutions, and sold many bottles of it to gunsmiths and amateurs, who used it, in

most cases, with very good results. Griffin & Howe state that they use a similar solution, which they call Old English Gun Bluer on hurry up jobs in their shop, but use a slower process where time permits. This solution is also for sale on the market. Mr. Fecker, known to target shooters for the excellence of his rifle telescopes, also markets a similar solution made on a formula supplied by Mr. James V. Howe.

I have used both the Hoffman and the Fecker solutions; I have seen the Old English Bluer used in another shop; and from this experience, as well as having seen Hoffman solution used in the Hoffman shop, will say that all are good, and, in my opinion as good as an all round, easy-to-use solution can be made. They have the disadvantage, however, of falling down on the job at most unexpected times, and for no apparent reason. When this occurs the barrel under process takes on a brownish tint instead of a blue-black; it shows streaks where the bluing was applied, and these streaks are not eradicated by subsequent applications. They usually occur early in the process, and if a first class job is expected, it is best to repolish the barrel and start the job over again. They possess another disadvantage in that they require the use of soft water, often impossible to obtain, particularly in the city.

In addition to the three solutions referred to there are a number of Toms, Dicks and Harrys running ads offering to send you a bluing solution formula for four-bits, a buck, or what have you. Save your money! Public libraries are full of old recipe books that tell you how to make everything from mustard plasters and ringbone remedies to near-Scotch. Get hold of such a book and you can

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start peddling antiquated and obsolete formulas too—and can keep it up just as long as you can find a sucker.

The whole trouble, as I see it, with ready prepared solutions is that they have been worked out to apply to conditions in one particular shop, and usually on one variety of steel. I can scarcely take credit for originating the formula for the solution I have come to use and depend on; it has been developed, largely by cut and try methods, from older formulas, changing ingredients as seemed necessary, for the work in hand. And be it understood that this is not offered as an all-purpose solution; it is a basic mixture which, in my hands, gives perfect results on all government Springfield barrels and actions; and, with certain modifications which I shall describe gives equally good results on almost any steel or iron. For convenience in reference, formulas given will be numbered consecutively.

No. 1. HOT BLUING—BASIC SOLUTION:

½	oz. Sodium Nitrate
½	oz. Potassium Nitrate
½	oz. Bichloride Mercury
½	oz. Potassium Chlorate
10	oz. Distilled Water
½	oz. Spirits Nitre

The first four ingredients are powders. Mix them dry in a clean, wide-mouthed glass jar. Heat the water good and warm, but not boiling, and pour in slowly, stirring with a glass rod or tube, stirring continually until almost, but not quite cool; then add the Spirits Nitre, which will precipitate a light brownish powder. Pour immediately into a dark brown glass bottle with glass stopper and keep in a dark place. Shake the bottle before using, to mix up the precipitate.

VARIATIONS OF ABOVE SOLUTION:

On most case-hardened parts—receivers, lock plates, hammers, etc., add 20 to 40 grains more potassium nitrate, and an equal amount of potassium chlorate.

For .45-70 Springfield barrels, most .22 caliber barrels, and all old soft steel barrels, use only 1/4 oz. spirits nitre in above solution, and use 14 oz. distilled water instead of 10.

For Stainless Steel, Boehler Antinit and Poldi Anticoro, use solution with the addition of 1/2 oz. Tincture Ferric Chloride, 1/4 oz. Nitric Acid, and 1/4 oz. Hydrochloric Acid. Bluing these steels is a tough job, because bluing is a rusting process, and these steels are highly rust resisting. From thirty to forty applications are often necessary.

Other slight variations of this formula may be worked out for special jobs, but the foregoing have met my requirement to date.

No. 2. ETCHING SOLUTION:

Nitric Acid	½ oz.
Distilled Water	4½ oz.

When bluing Stainless, Antinit or Anticoro steel, use "Spencer Acid" obtainable from jewelry supply houses or chemists instead of this etching solution. In case this cannot be obtained readily mix up:

SPENCER ACID

Mix	
Silver Nitrate	½ oz.
Distilled Water	13½ oz.
Then add	
Mercurous Nitrate	½ oz.
Nitric Acid	5½ oz.

Put in brown bottle. Keeps well but light spoils it.

BLUING BY THE HOT SOLUTION PROCESS: Clean the work as previously described, and as quickly as possible thereafter, put into a tank of clean hot water. Shake up the bluing solution (No. 1, or one of the variations thereof) and pour an ounce or two of the mixture into a four ounce glass jar, such as a mayonnaise jar. *Be sure this jar is absolutely clean and free from grease.* Twist a piece of baling wire around jar and hang it in corner of bluing tank, so that it is down in the water. Cut a 6 inch length of clean dowel rod and slot the end for an inch with a hacksaw, and into this force five or six thicknesses of sterile gauze bandage. This makes the best kind of swab for applying the solution. Avoid the use of a thick wad of rags, or a pine swab-stick containing rosin.

Now bring the water in the tank to boiling point and let boil for several minutes. *WEAR CLEAN COTTON GLOVES ALL THE TIME,* and avoid touching them to anything that might be greasy. Remove the gloves if necessary to adjust burners or to handle anything but the parts you are bluing.

When barrel (or other parts) are thoroughly heated in the boiling water, lift out with iron wire hooks, and coat quickly with No. 2 Etching Solution, using a tuft of clean rag. Work very quickly, splashing on plenty of this solution, and try to cover the entire surface at a stroke or two. Keep going over it, both barrel and receiver, and keep the whole surface wet. In a very few seconds the steel will take on a slightly frosted silvery appearance. If inspection shows this to be uneven, coat the spots again and hold a few seconds. Otherwise, plunge instantly back into the tank and reheat for five minutes.

FROM THIS POINT ON THE WATER IN THE TANK MUST BE KEPT AT A HARD, ROLLING, BUBBLING BOIL—NOTHING ELSE WILL DO.

When the barrel is as hot as boiling water can make it, lift out and coat quickly with No. 1 solution. Press the solution out of the swab against mouth of jar, and *work as fast as you are capable of moving*—or a little faster. The barrel should be so hot that the solution dries off as fast as applied, leaving a slight bluish gray coating. And it must "take" all over the barrel and action. If spots are not affected by at least the third coat, it means the steel was not properly cleaned and etched, and the job is hopeless.

If the first coating is red rust, the solution is not right for the steel. Try diluting it with a spoonful or two of distilled water, or try one of the variations previously mentioned.

The barrel should be quite dry from its own heat within two or three seconds from the time the solution is applied. If it dries slowly, blow on it. The instant it is dry, put it back into the water and boil for a minute or two.

Now you can be more deliberate. Lift it out of the water, stand one end on a stool, bench or other convenient support, holding the upper end by the plug with the left hand. Take a handful of steel wool and scour entire surface with long, light, even strokes. Use just enough pressure to remove *all* the rust that has formed, clear to the naked steel—but don't rub off the slight color that has started. Use the wire scratch-brush to get into crevices in receiver, etc., and around front sight base. Use the brush briskly, but with light pressure. Any of the rust that is left on is likely to result in brown or uneven streaks and spots in the finished job, so get it all off.

Now put the barrel back in the water and let boil for several minutes; then apply the solution again just as before. Work "fast and furious" when applying solution, but take your time if you like when rubbing off the rust. No harm is done by leaving the parts to boil for several minutes after solution has been applied, hence,

you may blue all the parts at one time by coating them all one after another, and rubbing them off in the same order. Each small part should have a short length of wire attached so that it may be lifted out of the water when wanted.

In most cases from three to five applications and subsequent rubbings are sufficient for a first class job. Ten or twelve may be necessary, particularly on hard or very thin parts.

The secret of bluing small parts is to work almost on the surface of the water, coating them with the solution the instant they are lifted, and before they have started to cool. Also, keep the swab in the hot solution until the very instant of applying.

When the color rubs off, it usually means the parts were not hot enough. With small parts I sometimes apply solution three or four times, putting them back in the water a moment to re-heat, and not rubbing off the rust each time. This is often necessary on floor plates,—and a floor plate is the hardest thing I know of to blue. Next in order of plain cussedness comes a trigger-guard.

Bear this in mind—unless the solution dries from the heat of the part almost the instant it is applied, the job will not be right. Get that solution on *quickly*.

When several applications have brought out a rich blue-black color as dark as it will apparently become, give it a couple more

shots for luck, rubbing them down with a clean cotton rag instead of the steel wool, using the brush only where necessary—inside cuts, matted or engraved surfaces, etc., and using it *lightly*. Then put the parts back and boil them for five minutes or so to kill all further rusting.

If you have a motor or grinder it is well now to buff *very lightly* with a soft iron (not brass) wire buffer. This burnishes the surface and seems to deepen the color. If you have no buffer, burnish with steel wool that is well worn, rubbing lightly with long strokes. Then while parts are still very hot, apply plenty of boiled linseed oil with brush or rag. Let stand until nearly cool, when the oil will show a tendency to start gumming. Wipe it off carefully, and oil with any thin light gun oil. Remove the barrel plugs, wipe out bore, and the gun is ready to assemble.

All this is a lot simpler than it sounds. The job should take from an hour to an hour and a half. Some claim to do it in twenty to thirty minutes, but I can't.

I have never seen the etching solution recommended in connection with a bluing solution, but I am a firm believer in it. Often it will give a fine blue-black which would otherwise come out chocolate brown. I am convinced that failure with ready made solutions is often due to extremely high polishing of the surface, resulting in filling up the pores so that the solution cannot take hold. The No. 2 etching solution does not pit the surface, but merely cleans out and opens the pores, resulting in a fine velvety finish, far more practical than the high polish sought by some. The after burnishing with steel wool or buffer gives all the polish needed, and if a matte surface is desired, this may be omitted. If it is omitted, the resulting finish will be almost identical with that formerly seen on Savage '99 model receivers and Savage auto pistols.

No. 3. ETCHING SOLUTION:

Nitric Acid	½ oz.
Distilled Water	2½ oz.

Use this solution for pitting the surface of leaf sights, etc., where a very dull finish is desired. Such parts may afterward be blued by any of the methods described in this chapter.

No. 4. PICKLING SOLUTION:

Sulphuric Acid	½ oz.
Distilled Water	6½ oz.

Flush this on the surface of an old gun with finish partly worn off and it will remove every bit of the finish, leaving the steel bright. Then flush off with plenty of clean boiling water. This avoids much needless scouring to remove old finish—only polishing is necessary unless there are deep nicks and scratches which must be filed and polished out.

No. 5. ZISCHANG BROWNING SOLUTION:

This is published through courtesy of Mr. James V. Howe. I have tried it on old guns with soft steel or iron barrels and with excellent results. The color is a deep brownish black with an attractive translucent appearance, and very durable.

Muriatic Acid	10 oz.
Nitric Acid	10 oz.

Mix the acids in a glazed stone jar, *out of doors*. Let the mixture cool—it gets "hotter'n hell" for a few minutes—then put in 4 ounces of common wire nails. Keep away from the thick brown vapor that arises, or wear a gas-mask if you must watch it. In half an hour the nails will be completely dissolved. Then add 240 ounces distilled water, and bottle in brown or blue glass. A fourth of the above quantities will give you all the solution you will need for some time to come.

Instructions for Use

Clean barrel as previously described, and after final boiling in clean water, dry and cool. Apply solution lightly with clean swab, and let barrel stand in cool damp place for 12 hours, when a heavy coat of rust will be formed. Scour off with steel wool and scratch brush; boil in clean water for five minutes, dry, cool, and re-coat with solution. Repeat every twelve hours for 10 days. After final scouring, boil, dry, and oil with linseed oil, followed by light oil after cooling.

No. 6. COLD BROWNING SOLUTION: This is the solution recommended by Col. Townsend Whelen in Amateur Gunsmithing, and has been used by hundreds of gun-cranks and professionals with excellent results:

Tincture Ferric Chloride (U. S. P.)	1 oz.
Alcohol (95% by volume)	1 oz.
Bichloride of Mercury	½ oz.
Nitric Acid (sp. gr. 1.46)	½ oz.
Copper Sulphate	½ oz.
Distilled Water	1 qt.

This should be made up a few days prior to use, and kept in brown glass bottle with glass stopper. (Any large drug or chemical supply house accumulates many 8 ounce brown glass acid bottles with ground glass stoppers lapped to a perfect fit. They may be bought for a few cents each, and nothing better will be found for the purpose.)

This solution is used in the same manner as the Zischang solution, except that Col. Whelen says nothing about boiling the barrel after rubbing off each coat of rust. I find it desirable, though not absolutely necessary, to do this, as each boiling kills all chemical action of the previous coating, and gives the next application of solution a fresh start. This tends to eliminate any tendency toward spots or streaks.

No. 7. COLD BROWNING SOLUTION: According to Captain E. C. Crossman, who certainly should be in a position to know what's what in the gun factories, the following solution has long been standard in the Savage plant:

Spirits of Wine	4½ oz.
Tincture of Iron	1½ oz.
Corrosive Sublimate	1½ oz.
Spirits of Nitre	1½ oz.
Copper Sulphate	1 oz.
Nitric Acid	½ oz.

Dissolve the solids in one quart of pure water, then add the spirits of wine, tincture of iron, nitric acid, and spirits of nitre.

This solution is applied to barrels as already described, but most large factories hasten and improve the job by the use of a steam room or cabinet. This is merely a small room or large cabinet made air tight and provided with racks where the barrels may be arranged without touching, and treated with live steam for three to six hours. The rust coat is scoured off, and treatment repeated—three rustings being the usual rule in most factories. Crossman also describes the following formula used by the United States government:

No. 8. COLD BROWNING SOLUTION:

Tincture of Iron	8 oz.
Sweet Spirits Nitre	8 oz.
Nitric Acid	1 oz.
Corrosive Sublimate	1 oz.
Copper Sulphate	½ oz.
Distilled Water	2 qts.

Mix in the order given, and apply like the other solutions. Barrels are kept in steam room for 24 hours after first application; then scoured, after first being boiled in water; then coated again and placed in steam room for 3 hours; boiled again, scoured off, re-coated, steamed for 3 hours more, boiled, scoured, and oiled.

No. 9. COLD BROWNING SOLUTION: This is another U. S. government formula given in "United States Rifles and Machine Guns" by Colvin and Viall. This is a most interesting and valuable book to all rifle cranks, by the way. It costs but three dollars, and is worth three hundred. I am under the impression that it was prepared as a manufacturing guide to the production of our service arms, during the emergency when contracts with private manufacturers were contemplated. The formula follows:

First, prepare a "tincture of steel" by putting 3 pounds of carbonate of iron in a stone jar and adding 3 quarts muriatic acid; stir until the acid has dissolved all the iron it will take up, then pour off carefully, into glass demijohn, being careful to keep out the sediment, and add 9 quarts grain alcohol. Then—

Tincture of Steel	8 oz.
Spirits of Nitre	8 oz.
Nitric Acid	1½ oz.
Copper Sulphate	½ oz.
Corrosive Sublimate	1 oz.
Soft Water	8 qts

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The process is similar to that used with Solution No. 8, except that each coating is steamed for only 1 hour, there being three coatings in all. Each coating of rust is boiled for five minutes before carding off.

From the foregoing it is evident that there are quite a number of solutions both home-made and of the "store" variety, any of which will, with proper persuasion, blue a gun. I have in addition about a dozen other formulas that I have never tried, simply because I don't need them, and as they are somewhat obsolete would expect no better results from their use. I personally do not care much for the slow rusting processes which are applied cold. They require the same equipment (tank for boiling) as the quicker hot solutions, and their use entails considerably more work and time. And of all the methods I have used for barrels and receivers, the No. 1 Solution gives, in my hands, the best results.

The various heat processes are somewhat more difficult to handle, especially in unskilled hands, but are, nevertheless more desirable for revolvers and pistols, as well as for many small parts which are not tempered, case-hardened or heat treated. Obviously such parts would be ruined by bluing methods calling for high heats, and must therefore be finished by one of the solution methods.

No. 10. NITRE BLUING: This is one of the best known bluing methods, having been described in gunsmithing articles in several magazines during the past few years. Different operators vary the proportions somewhat, but the usual formula is:

Sodium Nitrate	10 pounds
Potassium Nitrate	10 pounds
Manganese Dioxide	1 to 2 pounds

Some shops eliminate the sodium nitrate and double the quantity of potassium nitrate Others reduce the quantity of manganese dioxide.

The nitrates should be melted in a castiron pot or kettle, and the black oxide added after they are melted. For small parts a pot such as is used for melting bullet metal is satisfactory. For large parts, revolvers, etc., have a castiron box made at the nearest foundry, about 5 by 8 inches by 4 inches deep—or larger if necessary. A wooden box of the right size, with sides slightly tapered for "draw" will serve as the pattern.

Set the pot or iron box on a large gas burner or a plumber's gasoline blast furnace, and put in the nitrates. Add more as they melt down until the box is nearly full. When melted, add the black oxide, and heat the mixture to a point where it will just ignite sawdust or a thin pine splinter.

Parts to be blued should have a much higher polish than is required for solution bluing. Buffing does not hurt them in the least—the higher the polish, the better the color to be obtained by this method. Attach them to iron wires or hang them on hooks in

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the mixture for about three minutes, after cleaning by boiling in lye and rinsing in boiling water. Lift out at the end of three minutes and inspect color. The first blue will be a bright tempering color—pay no attention to this, but put the parts back. In four to eight minutes a deep rich blue should appear, and this should be even over the entire surface. If not, put them back for a minute or so longer. When color is right, quench quickly in good hot (but not boiling) water. Then oil with heavy bodied gun oil, or use linseed at first and lighter oil when parts are nearly cool.

Sometimes the job is improved by a second heating in the nitre bath after the first water quenching. At other times the second treatment seems to have no effect. Be sure there is no oil or water on the parts when putting them in. Oil will burn and cause ugly spots, while water will cause the nitre to pop and sputter over your face and hands, causing nasty burns.

One of the most beautiful and lasting finishes I have been able to obtain, is done as follows:

Blue parts in nitre as just described; after quenching, and without oiling or touching, bring the water to a hard boil, and re-blue with No. 1 Solution. The rust coating that forms will be very light and soft, and is easily rubbed off with a rag. Three or four quick applications only are needed, after which the parts are boiled and then oiled. The finish produced is deep and brilliant, and for beauty is not surpassed by Winchester's best barrel finish. Parts that are already nitre blued may be greatly improved by this treatment—using the solution right over the original bluing, after boiling off the oil and grease.

No. 11A. CHARCOAL BLUING: An old English gunmaker gave me the following, which I have seen him use to produce very fine work, although I have never used it myself:

Make a box of heavy sheet iron large enough to hold the largest part to be blued. It is not necessary to rivet or weld the box—merely fold the corners. Fill it with pulverized wood charcoal in lumps about the size of a small pea, and heat in furnace or large forge until the charcoal is partly burning throughout, but not quite redhot. Attach an iron rod at least two feet long to the gun, and bury it in the glowing mass, allowing the rod to stick out for handling. In 5 to 10 minutes, lift out and examine it. If the color has started, take a large wad of clean cotton waste or tow, dip it into dry powdered lime and rub vigorously over every part of the gun. Get it back into the glowing charcoal as quickly as possible. Repeat this treatment every 7 to 10 minutes, using plenty of lime and rubbing it into every part and *work fast*. You may be fooled at the first bright blue that appears. This is merely a "tempering color" and must be disregarded. It will not wear, and it is not the blue you are after. Continue the treatment until a deep blue-black similar to that seen on Colt revolvers has developed. Let

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cool in the air (do not quench) then apply any good light gun oil.

The process may be repeated a second time if desired, usually deepening the color. The parts must of course be cleaned of all grease, just as for any other bluing process. Many gunsmiths do this by applying a mixture of chalk and water, letting it dry on the gun, then brushing it off.

A variation of this method was at one time used by Smith & Wesson, except that the gun was rubbed with oily waste instead of lime. Either method requires considerable skill and experience but the results fully justify the effort.

No. 11B. HEAT AND OIL BLUING: This method is my stand-by for small parts such as screws, sights, pins, swivels, barrel bands, sling loops, buttplates, etc., where the article is of such size and importance as not to warrant heating up the nitre box. Mix up:

Linseed Oil (boiled or raw)	8 oz.
Marble's Nitro-Solvent Oil	8 oz.

Keep this oil in a wide mouthed jar or can with screw or friction top, and it is always ready for instant use. Parts may be held on a stiff wire, or in a pair of tongs or pliers. Heat the parts in a gas flame to a dull red (below cherry red); hold at this heat for a minute or so, then quench in the oil mixture; lift out for a second or so before quite cool, and re-dip immediately. Keep the parts moving in the oil. This is the best method I know of for small or thin parts that are hard to blue with a solution, and the results on small parts are fully equal to original factory finish in appearance and wearing qualities. There will be no scale formation at the heat used in this process.

LAMPING. Slight alterations may result in bright spots where a little filing or polishing was necessary, and these spots can be reblued in most instances without refinishing the entire gun. Holster-worn spots on a pistol barrel; a shiny muzzle resulting from fitting a front sight band; these are subjects for the simple heat-bluing process known as "lamping."

First rub off all oil with a clean cloth. Then etch the spot for a moment with a 1 to 13 solution of Nitric acid in water; or omit this etching if desired, although it will improve the finish. The solution should be washed off with clean water almost immediately —just as soon as it "takes hold" of the metal. Then dry with a clean cloth, and hold the spot in a gas flame or blow torch and watch the colors. Pay no attention to the tempering colors—wait until all the colors have appeared, including blue. This tempering blue will change to a lighter blue, then to the natural bright color of the steel; a moment later the metal will turn dark, almost black; remove from the flame, watch the spot for a moment; at the least sign of the natural color returning, put it back into the flame. "Tease" the metal in this way for several minutes, trying to hold

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it at that heat at which it is very dark, just before red begins to appear. Then remove from the flame and rub vigorously with a handful of rags or waste lightly saturated with a mixture of 2 parts boiled linseed oil and 1 part Marble's Nitro-Solvent. At first the oil will smoke, and burn slightly. Work fast, and keep taking clean spots on the rag or waste, and continuing the rubbing until the oil stops smoking, and for a minute or two longer. The barrel will still be quite warm. Now scour the spots with a soft wire brush, or buff lightly on wire buffer until the oil spots caused by the burning oil are rubbed off and the metal burnished; then continue rubbing with the oily waste until barrel is nearly cool. Wipe off all oil, and coat with gun grease.

Spots treated in this way, while they may not match the rest of the color exactly, will greatly improve the appearance of a gun having worn or scratched places, and often the colors will match almost perfectly.

When lamping out spots in this way, you may be alarmed to see the good bluing being somewhat discolored by the heat. Rest easy—those colors on the bluing are only temporary, and the minute you start rubbing with the oily waste, they disappear.

On a gun whose finish is perfect but for one or two small spots, it will pay to use a blowtorch with a very small, pointed, hot flame, and make a mask of sheet asbestos with a hole just slightly larger than the spot.

Lamping should not of course be attempted on hardened or heat treated parts, nor on parts attached with soft solder. Brazing will not be damaged by this process.

NEW METHOD GUN BLUER. This is simply a metal lacquer colored to a purplish, bluish black, and sold at one dollar per small can for the alleged purpose of bluing guns. It will "blue" them, the same as a coat of paint blues a house—if you use blue paint. The crank will not enthuse very much over the appearance of an arm finished with New Method, but it will cover a certain amount of the scabbiness of some rusty old wreck which the owner may desire to unload upon an unwary victim who thinks he is buying a gun. One of the best things about this preparation is that it is easily washed off with a little denatured alcohol.

Having thus thoroughly damned it, I must now confess that I keep a can of New Method on hand in my shop, and find it very useful for touching up the end of a drift pin now and then, or some other tiny spot such as the edge of a sight that has become slightly marred, or something of similar nature. It is worth having around for such uses, but as a satisfactory means of finishing guns or parts, this or any other paint or lacquer is entirely out of the running. Good workmen won't use makeshift methods.

No. 12. HEAT AND WATER BLUING: Once in a while you will find a part which from sheer cussedness apparently will

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not take a satisfactory finish. Usually it is some part that has been case-hardened, or one made of some unusually hard steel. Krag buttplates are particularly obstinate in this respect, and while on a butt plate is the last place in the world to worry about finish, still, it is a good idea to have the job leave your shop looking like something had been done to it. If the part is not one having a temper or heat treatment that must be preserved, just heat it a dull red as in No. 11, and dip into boiling water. Keep a burner going under the water. It's surprising how long a part will stay redhot under water! The color thus produced is a grayish blue, lighter than the oil blue, but very even, and one that no one will object to on a buttplate.

The subject of case-hardening for colors has already been discussed in another chapter, and need not be considered further here.

There are, however, times when the gunsmith will want to make some small part such as a grip cap, or perhaps even a buttplate, from some softer metal more easily worked than iron or steel. Brass, copper, bronze, aluminum, etc., may readily be finished in almost any color desired—one is not by any means confined to black or gun-blue, but may give free reign to his fancy and often produce some beautiful effects.

I have used several of the following formulas with highly satisfactory results. I give others which I have not used simply because I have not required them, but have no doubt of their efficacy as they are taken from technical works prepared for the plating and metal finishing trades, and many of them are well known to platers.

No. 13. CLEANING AND PICKLING:. Almost all soft metals may be cleaned by first scrubbing with a stiff brush and pumice with water, then boiling in solution of caustic soda or potash for a few minutes. Then rinse in clean warm water and dry with clean cotton cloth, and avoid handling during coloring processes. The following is an excellent pickling solution for brass and all copper alloys:

Nitric Acid	100 parts
Salt	1 part
Common Soot	1 part

Dip the articles only a few seconds and wash immediately in clean warm water. This leaves a fine luster in the true natural color of the metal.

No. 14. DEAD PICKLE:

Potassium Bichromate (Saturated Solution)	1 part
Hydrochloric Acid	3 parts

Leave articles in this mixture for two or three hours, or longer if necessary. When the surface presents a "dead" appearance—natural color of the metal, with absolutely no gloss or lustre—wash through several waters.

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No. 15. BLACKENING SOLUTION—ALUMINUM:

White Arsenic	1 oz.
Iron Sulphate	1 oz.
Hydrochloric Acid	12 oz.
Distilled Water	12 oz.

Scour the aluminum with pumice and water, then in a very weak lye solution and rinse immediately. Immerse in above solution, slightly warmed, until black. Dry in fine clean sawdust, then lacquer.

No. 16. BLACKENING BRASS:

Hydrochloric Acid	2 parts
Nitric Acid	1 part

Warm in glass bowl on a sandbath then dissolve as much platinum foil in the mixture as it will take up. Do not let it boil. After pickling brass in Solution 13 or 14, warm it slightly and dip into the blackening solution, or paint it on with a brush. When black, remove and wash in warm water, dry in sawdust. This is the dead black finish used by manufacturers of optical instruments, and is expensive to make, due to the use of platinum. It is a most durable finish, however, and should appeal to the experimenter in sights or scopes, as the best finish for this purpose.

No. 17. BLUE-BLACK FOR BRASS.

Copper Carbonate	1 oz.
Stronger Ammonia (25 to 35% gas)	3 pints

When above ingredients are mixed a precipitate will be formed. Then add 1 quart warm water, and immerse the brass until the color comes, then wash and dry as before.

No. 18. BLACKENING BRASS:

Corrosive Sublimate	1 oz.
Vinegar	1 pint

Clean and pickle brass as before, wash, and dry. Brush the solution on and let it remain until brass is black. Wash thoroughly in clean warm water, dry, and rub in finely powdered graphite with soft brush. Lacquer if desired.

No. 19. BLACKENING BRASS:

(a)	Copper Nitrate ..	50 parts	(b)	Potassium Sulphide .	10 parts
	Water	100 parts		Hydrochloric Acid ..	5 parts
				Water	100 parts

Clean and pickle the brass as before, then immerse or paint on solution "a" with soft rag swab, rubbing it in gently, then heat over a gas flame until dry and greenish salts are formed. Then immerse in solution "b" for a few minutes, and heat again until dry and the color black. Wash in warm water, dry and lacquer.

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No. 20. OLIVE GREEN ON BRASS:

Copper Sulphate	8 parts
Sal Ammoniac	3 parts
Water	100 parts

Suspend the brass parts in this solution and boil, leaving parts in until color is obtained. Wash thoroughly and dry in sawdust.

No. 21. BRIGHT RED FOR BRASS:

Potassium Chlorate	75 grains
Nickel Carbonate	30 grains
Salt of Nickel	75 grains
Distilled Water	10 ounces

Immerse the brass for a considerable time and watch the color. In a few hours it becomes a yellow-brown, which later changes to a brilliant fire-red. Those who advocate the use of a bright red bead on front sight may make it of brass and this solution will produce a color that will make a bull paw up the turf!

No. 22. IRIDESCENCE ON BRASS (ALSO COPPER AND NICKEL):

Lead Acetate	1 part
Sodium Hyposulphite	8 parts
Water	40 parts

Immerse articles in solution and let stand until desired effect is obtained; rinse in clean water and let dry without rubbing or touching. The colors will be beautiful, and very lasting.

No. 23. BRONZE ANTIQUE FOR BRASS:

Vinegar	1 litre
Copper Sulphate	16 grams
Sea Salt	32 grams
Sal Ammoniac	32 grams
Sanders green (mountain green) . . .	70 grains
Ammonia	32 grams

Immerse the brass, or spread it rapidly with soft brush. The object will turn a greenish color. Remove excess liquid lightly with long bristled brush, and let dry 24 hours. Additional coatings may be applied if desired.

No. 24. BLACKENING COPPER:

Dip parts in pure nitric acid, remove, and heat to a dull red. Let cool, wash, dry, and oil or lacquer.

No. 25. BLUING COPPER:

Liver of Sulphur	1 oz.
Chlorate of Soda	1 oz.
Water	500 oz.

Immerse or paint on solution until blue color is obtained; wash, dry and lacquer.

No. 26. BROWNING AND BLACKENING COPPER:

Nitrate of Iron	5 drams
Water	1 pint

Immerse parts in solution until desired color is obtained—colors will range through all shades of brown to deep black. Remove and wash, dry in sawdust, and lacquer.

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No. 27. BRIGHT RED FOR COPPER:

Sulphide of Antimony	2 drams
Pearlash	1 oz.
[redacted]	1 pint

Use same as Solution No. 26.

No. 28. RED-BLACK FOR COPPER:

Sulphur	1 oz.
Pearlash	1 oz.
Water	1 pint

Use same as Solutions 26 and 27. Gives all shades of red, deepening into black.

No. 29. ROYAL COPPER:

Sulphide of Antimony	2 drams
Pearlash	1 oz.
Water	1 pint

Immerse until desired color is obtained—a very intense red.

No. 30. SILVERING COPPER:

Silver Nitrate	60 grains
Common Salt	60 grains
Cream of Tartar	7 drams

Moisten with a little water and apply with a soft cloth until the copper is plated with a light coating of silver. Wash, dry and lacquer.

No. 31. BLACKENING NICKEL:

Nickel-Ammonium Sulphate .	14.02 grams
Potassium Sulphocyanide .	85.05 grams
Copper Carbonate	56.70 grams
Water	3 litres, 785 grams

Immerse until nickel is black. Then wash, and dry. I have never used this solution, but it is highly recommended by an old experienced finisher, as giving a very rich, deep velvety black color. It is not the "black nickel" plating process in which the nickel deposited is black clear through. The plating process is still regarded as a trade secret, and I have been unable to secure any formula that I could guarantee to work. It would appear that this No. 31 solution might prove valuable for nickel plated revolvers, etc.; also, that any barrel, particularly those of stainless steel which are very hard to blue, might be nickel plated and treated with this solution. Similarly, a gun could be copper plated at small cost, and blackened with solutions 24, 25 or 26.

No. 32. BLACKENING SILVER:

Rub the object with a solution of silver nitrate until black; wash and dry. Or, dip in any alkaline sulphide solution, then brush with cream of tartar.

No. 33. BROWNING SILVER:

Dip in solution of equal parts of sal ammoniac and copper sulphate dissolved in vinegar. This gives a deep brown color. Afterward, wash and dry.

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No. 34. OXIDIZING SILVER:

[redacted]	8 grains
Potassium Bromide	120 grains
Water	10 oz.

Boil silver in this solution 2 to 5 minutes, then polish with rouge.

No. 35. BLACKENING ZINC:

Nickel Ammonium Sulphide	4 parts
Sulphuric Acid	1 part
Water	40 parts

Clean zinc by scrubbing with fine sand, pumice or emery, and immerse for a few moments in suphuric acid. Then immerse in above solution for only an instant or so, wash through several waters, and dry. This gives a very fine black color which becomes a bronze tint if burnished.

The amateur designer who has a leaning toward the artistic will find keen enjoyment in working out some new "gadget" for his gun or rifle. Perhaps it will be only a simple monogram plate inlaid in the stock; or it may take the form of a grip cap or forend tip modeled in clay or plaster, and cast in one of these soft metals. With this thought in mind I have given formulas for finishing metals not usually considered in gunsmithing—yet these are but a few of the colors that may be obtained with other formulas available.

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CHAPTER 21

ANNEALING, HARDENING AND TEMPERING

TO BE able to devote but a single chapter to this all-important subject is somewhat disconcerting, and, in the light of the many volumes published in recent years, perhaps foolhardy. To really understand hardening and tempering of steel and iron an extensive study of the character of the metals, their structure, and the manufacturing processes by which they are produced is essential.

But since this book applies to the field of gunsmithing as a whole, and is not confined to any special branch of that subject, all I can hope to do is to give the reader an outline of practical methods evolved by leading authorities, and touching but lightly on the theories and formulae on which such practices are based. To encourage the most complete understanding of the technique herein explained, some discussion of fundamentals is essential.

STEEL is an alloy, composed principally of iron, with additions of Carbon, Chromium, Vanadium, Nickel, Manganese, Tungsten or other substance—any one of these, and sometimes a combination of two or more. Many steels also contain minute quantities of copper, and a small percentage of impurities, although modern steel manu-

facturing processes have reduced such impurities to a minimum.

Pure iron—that is, iron containing no element to change it into steel—is almost unknown commercially today. For some reason the production of pure iron is expensive, and low grade steels are used almost universally instead. The early backwoods riflemaker welded his barrels from pure iron which he or perhaps some of his neighbors mined and smelted by the most primitive methods—yet methods which resulted in iron of the finest and purest grade. Their steel was made by combining carbon with this iron in an open forge, working it in at welding heat. By this simple means they produced carbon steel of fine quality, yet varying in its carbon content by reason of the method employed.

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Steel making is today one of the exact sciences, the proportion of carbon or other hardening element being carefully controlled to produce special material best adapted to its particular purposes. Yet no existing process has been perfected to the point of absolute, unfailing uniformity. Large plants employing quantities of steel must make laboratory tests of every batch obtained from the mill to determine its suitability and methods of treatment. When this fact is realized, it will be readily understood that no set rules can be laid down for use in every instance. Everything said in this chapter must be taken as applying in a general way, and individual experiment must govern final operations.

The piece of steel from which the gunsmith makes a spring, for example, may be somewhat different in composition and characteristics from that used in the tables herein presented; the tempering color you find it necessary to employ may vary a shade or two from that specified—and your next one may require slightly different handling from the last. And while each job thus presents its own peculiar problems, a general understanding of underling principles will facilitate their ready solution.

Our principal consideration will be carbon steels, since they are best adapted to the use of the gunowner with a basement workshop, as well as the average professional gunsmith; moreover, they are the least expensive, as well as the most readily obtained, particularly in small quantities. A list of the various tempers used in commonly known tools will prove of value; but first, we must understand the two distinct meanings of the word "temper."

To the steel maker, *temper* means the percentage of carbon the steel contains, regardless of the hardness or softness of the finished metal. But to the steel user (tool maker, machinist, etc.) temper signifies the degree of hardness he imparts to the finished article by his heat treatment.

The term *point* is used to denote carbon content, a point being one *one-hundredth* of one per cent. Thus a 100 point steel contains one per cent of carbon, 60 point steel contains 6/10 of one per cent carbon, and so on.

Razor temper, (to use the steel maker's term) or razor-steel, is about 150 point, or 1 1/2 per cent carbon. It is so easily burnt that only the most skilled worker can handle it; yet with proper treatment it will do many times the work of the best tool steel.

Saw-file temper is 137.5 point, or one and three-eighths per cent carbon. It, too, requires careful treatment, and should never be heated above a low red.

Tool temper is 125 point—one and one-fourth per cent carbon—and is adapted to machine tools and cutters of various sorts for lathes, drills and planers. In recent years, Tungsten self-hardening steels are gradually replacing carbon steels for machine tool operations.

Spindle temper is 112.5 point, or one and one-eighth per cent

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carbon. It is used for large turning tools, circular cutters, screw thread dies, etc.

Chisel temper is 100 point—one per cent carbon. For tools requiring a hard cutting edge, with great body strength and ability to withstand shocks, it is ideal. Properly tempered it is excellent for hammers and triggers, and other gun parts subject to considerable wear and strain, although harder than really necessary for such work.

Set temper is 87.5 point, or 7/8 of one per cent carbon. It is really better for most gun parts than the harder grades. Its strength is indicated by its extensive use in stamping and pressing dies, where ability to withstand enormous pressure is important. When a steel maker speaks of "very hard" steel, he means 150 point or harder; "hard" refers to 100-120 point, and "medium" to 70-80 point. It makes no difference whether the steel is annealed or hard when sold—the above terms apply only to the carbon it contains.

Carbon steels are made by two processes—the crucible process and the open hearth process, both of which have merits peculiar to themselves. While a description of such processes would undoubtedly be of interest, it would occupy too much space and do little or no good. What we are interested in is the best steel for making gun parts, and perhaps some of the tools we need, and how to make and temper them to do their work properly. Since most supply houses carry a somewhat limited stock of steel, and since in many instances we may want to make parts from old tools or other articles easily available, a general list of steels commonly used in various tools, etc., will likely prove valuable. The following is an extract from table in Woodworth's *Hardening, Tempering, & Annealing*.

	Carbon				Carbon	
Auger, wood	0 60	to	0.70	Jaw, vise	0.55	to 0.90
Axe	1 00			Knife, belt	0.80	to 0 85
Ball bearing	1 20			Knife, paper	1.05	to 1.10
Barrel, gun	0 60	to	0.70	Knife, wood working	1.15	to 1 20
Bits, mining	0 80			Knife, putty	0.90	to 1.00
Blade, pocket knife	0 90			Magnet	1.25	to 1.35
Blade, reamer	1 20	to	1.25	Machinery, crucible	0.55	to 0.65
Bushing, spring	0 80			Mower, lawn	1.00	
Centers, lathe	0 60	to	0.90	Plow, crucible	0.65	to 0.90
Chisels, cold	0 85			Punch, blacksmith	0.80	to 0 85
Chisels, chipping	0 80	to	0 90	Rake	1 15	to 1.25
Chisels, wood working	0.60	to	0.70	Saws, circular	0 80	to 0.90
Dies, envelope	1 10			Saws, for steel	1.00	
Dies, drop forging	0 85	to	0.90	Saws, cross cut	0.85	to 1 00
Drills, twist	1.20	to	1.25	Saws, band	0 65	to 0.75
Driver, screw	0 60	to	0 70	Skate	1.15	
Edge, straight	1.00	to	1 10	Spring, common locking	1.20	to 1.25
Facing, anvil	0 85	to	0.90	Spring, railroad, or locomotive	0 90	to 1 10
Files	1 25	to	1 30	Tape	1 20	to 1.25
Hammer, blacksmith's	0 87	to	0 75	Tools, blacksmiths'	0 60	to 0.70
Hammer, machinist's	0 90	to	1 00	Tools, moulders'	1.25	to 1.30
Hatchet	1 10	to	1 25	Tools, bricklayers'	0 90	to 0 95
Hoe	0 85	to	0 90	Wrenches	0.80	to 0.90
Hooks, grass	0.60	to	0 70			
Jaw, chuck	0 85	to	0 90			

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From the foregoing it will be evident that many odds and ends of old tools may supply steel that is well adapted to making springs or other parts of guns; it will be equally evident that others will *not* supply suitable material, for which reason they are shown herein. Many old time gunsmiths are in the habit of making a small part from any bit of metal that is handy, without the smallest inkling of its suitability.

The practice of making parts from old tools, etc., is not to be condemned—on the contrary, the knowledge of the temper of such tools will often prove a more reliable guide than some material salesman's word.

For gunsmiths who have access to a large machinists' supply house carrying a fairly complete stock of steel, it is advisable to lay in a small supply of short lengths (a foot or so will be sufficient) of the several grades likely to be needed. This stock should be plainly labeled with the kind of steel and carbon content, and placed conveniently in pigeon-holes or small bins. The following list is suggested as likely to cover most requirements:

Drill rod (tool steel, 1.25% C) in sizes to make various pins, etc., and in sizes from ¼" to ½" for checking tools, screw drivers, etc.
Drill rod (flat) in sizes adapted to various flat springs; also in sizes ⅛" x ⅝" to ¼" x ½" for forging special chisels, gouges, etc.
Annealed tool steel in ⅛" x ⅝" bar, and in ⅜" x ⅝" bar, for various small parts, sights, etc., and mechanism parts.
Cold rolled, or mild machinery steel in flat bars, ⅛" x ½", ¼" x ½", ⅛" x ⅛", ⅛" x ⅜", ¼" x ⅜", ¼" x ½", ⅛" x ⅜"
Thin "lock spring" (for cold bending) in widths of ¼", ⅜" and ½".
Piano wire, in various sizes likely to be needed for coil springs. (This is advisable whether you have a lathe for winding springs or not, for you can supply the proper size to the machine shop where you place your order, and avoid disappointment.)

While most small parts will be sawed and filed, or milled from the bar, it is advisable whenever possible to forge all pieces of irregular shape to something like their finished form. By so doing you can have the grain of the steel running in the direction of greatest strain, and this forging also seems to knit the fibers closer together, and strengthens the part materially.

But since this chapter deals with hardening and tempering, and not forging, we will proceed to that subject.

ANNEALING TOOL STEEL. The raw stock you buy in

the form of steel bars is usually annealed, to permit easy cutting and forming; but if you make a part from some old tool or other piece of tempered steel, it will be necessary to anneal it before you can work it. Factories employ great annealing ovens in which steel can be heated to predetermined temperatures, and cooled slowly at a specified rate; but such equipment is costly, and not necessary even

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to the good sized shop. The best way I know of to anneal an ordinary piece of hardened steel is to get up a good red bed of coals in the furnace, bury your steel in it and let the fire go out. This is particularly pleasing to friend wife if the thermometer is standing around zero and she is expecting guests to dinner.

Good annealing can be done in a forge if you will build up a good big bed of coals—the ordinary small working fire in a forge may let the piece cool too quickly for best results. But whether you use furnace, forge, or kitchen range, avoid heating the steel too hot, and too rapidly.

No air blast should be used—just a good bright fire that will bring the steel to a cherry red in two or three minutes without permitting it to pass that heat. In annealing—and this also applies to hardening—the lower the heat at which you can do the work, the better the job will be. Try first a *dull* red; if that fails, heat to full cherry red—but no hotter. Sometimes you will find steel that will not anneal at all, but is apparently as hard after the treatment as it was before. In such case you may know that you have a piece of tungsten or other air-hardening steel, and the best thing to do is to try something else. Air hardening, or self hardening steel is only adapted to high speed cutters, drills, etc., and is usually worked by grinding. It can be annealed, but the process is long and complicated, requiring expensive equipment.

A method practiced in many shops is to heat the part to be annealed cherry red and burying it in lime until cool; or it may be buried in hot ashes, powdered charcoal, hot sand, or almost any material that will prevent rapid cooling. Very small parts that have been hardened and must be annealed may be heated cherry red and clamped in the vise between two blocks of soft wood, so that the steel burns itself an airtight pocket and cools slowly.

Or it may be heated and placed between two larger pieces of redhot iron. The larger pieces, cooling more slowly, will retard the cooling of the smaller part.

When only a gas burner is available, the steel may be suspended in the flame, and brought to a red heat; adjust the burner to hold this heat and leave it for several minutes; turn the burner down a little at a time, so that the cooling extends over a half hour or so. Another way is to heat the part then place it in a very hot kitchen oven, lowering the temperature very gradually.

WATER ANNEALING. The author is familiar with two methods which are quite satisfactory for carbon steel in most cases, particularly where the carbon content is not too high. The first method consists of heating the steel to cherry red, then let it lie until the red has almost disappeared—in other words until it is black hot; then quench it in thick soapsuds.

The second method is to heat the steel red hot, then remove it quickly to a dark closet, letting it cool in the air until the red is no

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longer visible in the dark, then drop it into hot (but not boiling) water.

These methods will not remove all the temper, perhaps, but will soften the steel so that it can be readily cut and drilled, and this is often desirable practice where it is not planned to re-harden and temper the finished parts.

It must be borne in mind that any steel parts should be carefully annealed after forging, as the forging and subsequent cooling in the air will almost surely have caused some hardening; consequently the necessity for annealing before the final hardening and tempering processes. Moreover, the forging and cooling may have resulted in slight internal stresses in the parts, which the hardening might cause to warp badly. But careful annealing will relieve all such stresses, and the parts, if warped, may be trued up with little danger of warping in the hardening and tempering that follow.

One more warning against heating too hot when annealing! As a general rule, steel should be annealed at a slightly lower heat than is required to harden it; and the danger of burning the "life" out of the steel is much greater when annealing. Play safe—try annealing at a little lower heat than you think necessary; chances are it will work. And if it doesn't, just heat it a little hotter next time.

The tendency of most workmen is to demand softer and softer annealing, for easy working; whereas they should be educated to working it harder, for better final results. More steel is ruined by over-annealing than in any other manner. Over-annealed steel will shrink badly in the hardening, and is more liable to warping also. A little more "elbow grease" on the file, a little more time in the lathe or milling machine, will often pay big dividends in quality.

HARDENING. This section refers only to the hardening of carbon steel prior to tempering. Case-hardening of soft steel and iron will be treated later.

All steel has what is known as the "critical temperature"—the heat at which its structural formation undergoes a complete change necessary to the desired hardness. The critical temperature varies by several degrees in different steels, and is usually known only to the firm who made it; and since it could only be determined accurately by costly metallurgical tests, it is customary to assume, for practical work, that bright cherry red is the critical temperature. Here again, the worker must exercise care, for the same danger of overheating applies, as was mentioned in connection with annealing. Generally a slightly higher temperature than that used for annealing is advisable—but always use the lowest heat that will give the results required. If the part will not harden at a very bright red, you have probably made a mistake in the steel itself and are using machinery steel or cold rolled instead of carbon steel—either that, or else the steel has been "burnt" by heating too hot.

The general plan to be followed is to heat the parts, or tools, after

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they have been finished to shape and polish, to the critical temperature (or as near to it as practicable) and quenching in oil, oil and water, oil water and soap, soap, wax, grease, or plain water. Quenching in water makes the steel very brittle—too brittle for most uses. Oil, or some solution of oil, gives toughness and strength.

Uniform heating of irregularly shaped parts, or parts with holes in them, is often difficult; and as uniformity is very necessary, the practice of heating in hot lead, both for hardening and tempering is common. A cast iron box, or plumber's iron melting pot such as handloaders use for casting bullet metal, will answer nicely, provided it has been used considerably so that the sulphur contained in the castiron is burned out. A graphite crucible is best, but is expensive. Use chemically pure lead if possible for the hardening bath. Never use scrap lead of unknown origin as it always contains much sulphur, and this will ruin the steel. Bring the lead to a bright red heat, and hang the steel parts in it until they too are red. The heating will be absolutely uniform, and by controlling the heat of the lead it will be impossible to overheat the steel. If the parts are large it is advisable to pre-heat them nearly red in a forge before dropping into the pot, to prevent cooling the lead.

Keep the surface of the lead covered with powdered charcoal to prevent oxidation.

If the lead has a tendency to adhere to the steel parts, this may be avoided by dipping them first into a solution of potassium cyanide, in proportion of one pound to one gallon of water. Be sure they have dried thoroughly before putting them into the lead.

Sometimes it is necessary to heat and bend files to permit of their doing special work, afterward re-hardening them. To do this without risk of burning the points of the teeth, the U. S. Ordnance Department recommends the following mixture:

Pulverized charred leather	1 lb.
Fine family flour	1½ lbs.
Fine table salt	½ lbs.

The leather charcoal should be ground very fine, and put through a No. 45 sieve. Mix the ingredients dry add water slowly to form a stiff paste and prevent lumps, then add more water until the mixture is of the consistency of varnish. Spread it on the parts with a brush—a very thin even coat, and dry slowly, but thoroughly, over a *slow* fire.

The above mixture having been applied and dried the files or other parts are hardened in a lead bath as described.

Another well known formula for hardening files consists of:

Potassium ferro-cyanide, pulverized . . .	12 parts
Powdered charcoal	20 parts
Powdered rosin	35 parts
Powdered white glass	10 parts
Rye flour	85 parts
Neatsfoot, burned and pulverized . .	75 parts
Common salt	300 parts

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The ingredients are mixed with alcohol to form a thin paste, then spread on the work and dried before heating, similar to the Ordnance formula.

I have used the Ordnance formula, and have seen the other one used, and know that both are dependable. They absolutely prevent the formation of scale even when the steel is heated a bright red. Hammers with small sharp sear and safety notches, finished sears, and outside parts with a knurled or checked surface are perfectly protected with either of these mixtures.

They are extremely valuable also, for protecting the inside of a rifle barrel when necessary to braze on some part like a sling swivel, sight base, or binding-screw stud, or when filling up screw holes by electric welding. (See Chapter 23)

When using a forge for hardening, a charcoal or coke fire is best; anthracite is very satisfactory, but soft coal is no good—it contains sulphur which may ruin the steel. Heat the parts a little more quickly than when annealing, and see that the heat is as even all over the part as possible.

A gasoline blowtorch or plumber's blast furnace may be used in a pinch, but is not nearly so good. Have the torch as hot as possible, and move about in the flame to promote even heating. If an acetylene torch must be used, exercise great care to prevent overheating in spots, and play the flame rapidly over all surfaces, resting longer at the thick parts which heat more slowly.

The parts should not be held at the critical temperature longer than necessary—quench them as soon as they have an even color all over, and get them into the cooling bath the instant they are out of the fire.

The most common quenching bath, and the poorest for most uses, is cold water. Usually water, or some water solution is of more value in tempering than in hardening.

For hardening thin and delicate parts an oil bath is preferred. For hardening tools used for cutting, raw linseed oil is excellent; so is linseed oil and beef tallow, in proportion of 3 to 1. Lard oil, or sperm oil, are sometimes preferred to these, a sperm oil bath being considered best for steel springs.

The following formula was adopted by a firm making numbers of heavy duty springs: Spermaceti oil 48 parts; neatsfoot oil 45 parts; rendered beef suet 4 parts; rosin 3 parts.

There is no set rule for determining the best hardening bath. The coolant that works perfectly with one steel is worthless with another. Therefore it has been thought advisable to give several proven formulas, and only by experiment and some disappointment can the worker determine which is best for his use.

Some steel cannot be hardened sufficiently in oil baths, but hardens nicely in boiling water. Sometimes water at about 180 degrees solves the problem, while sometimes lukewarm water is best.

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Most hardeners using water prefer water that has been boiled, or rain water; while some assert that old water, that has been used for some time, is best. Some shops use a strong salt water, or "brine," for all hardening. This is good where extreme hardness is wanted. A pound of citric acid crystals in a gallon of water is also used for producing maximum hardness. Steel can usually be hardened at a slightly lower temperature in water than in oil solutions, but increased brittleness, and tendency to crack or break under stress of work, is more likely to result. A safe rule to adopt is to oil harden parts that have to endure great stresses and vibration, such as hammers, firing pins and the like, while parts that are only subject to surface friction may be water hardened. Many firearm parts, particularly shotgun parts, must be both "soft" fitted and "hard" fitted,—that is, before hardening, they are first worked to within a thousandth or so of final dimensions; then after hardening, they are brought to an exact fit with other parts in the mechanism by stoning, grinding or lapping and polishing.

TEMPERING. With very few exceptions, steel parts or tools must have the temper "drawn" somewhat to be fit for use. The hardening leaves the steel under great internal stress, and this stress is greatly relieved even by very slight drawing. Therefore, some drawing is essential even in parts requiring maximum hardness, otherwise they would be so brittle they would lack the strength to do the work required of them.

Some confusion has existed in the minds of amateur mechanics as to the principles of tempering. It must be understood that any piece of iron or unhardened steel that is polished, will run the whole scale of tempering colors as it is heated. *But, unless the steel has previously been heated to the critical temperature and hardened, these colors mean nothing, and have absolutely no effect on the hardness or strength of the steel.* When first hardened, as already described, then polished and slowly re-heated, the colors that appear indicate clearly the changes that are taking place, and the drawing of the temper to the exact hardness, stiffness and toughness that is wanted. This scale of colors given in order of their appearance, and the approximate temperature represented by each, is as follows:

Tempering colors of steel:

Very faint yellow	430 deg. F.
Straw color	460 deg. F
Dark straw	470 deg. F
Yellowish brown	500 deg. F
Purple	530 deg. F.
Blue	550 deg. F.
Full blue	580 deg. F.
Polish blue	530 deg. F.
Dark blue	600 deg. F
Pale blue	610 deg. F.
[illegible] and green spots	630 deg. F
Bright red in dark	725 deg. F
Redhot in twilight	884 deg. F.
Redhot in daylight	1077 deg. F.

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Don't attempt to "blue" a gun by these tempering colors—they mean nothing and the colors are not durable See chapter on "Bluing and Browning."

A list of commonly used tools, and the colors to which they are usually drawn, will prove helpful in determining the colors to use on many gun parts:

Augers	Light purple	530 deg. F
Hand reamers	Straw yellow	460 deg. F
Burnishers	Very light yellow	420 deg. F
Cold chisels for steel	Light purple	530 deg. F
Cold chisels for cast iron	Dark purple	550 deg. F
Collets	Dark yellow	490 deg. F
Woodworking chisels	Spotted red-brown	510 deg. F
Surgical instruments	Light purple	530 deg. F
Drills for brass	Straw yellow	460 deg. F
Gauges	Yellowish brown	500 deg. F
Milling cutters	Straw yellow	460 deg. F
Needles	Dark purple	560 deg. F
Penknives	Straw yellow	460 deg. F
Screw drivers	Dark purple	550 deg. F
Springs	Dark purple	550 deg. F.
Springs	Very dark blue	601 deg. F
Twist drills	Yellow brown	500 deg. F
All percussion tools	Blue	549 deg. F
Wood engraving tools	Very light yellow	430 deg. F

Thus it will be understood that hardening and tempering are two opposite operations: hardening is intended to produce all the hardness the steel is capable of acquiring; while tempering removes some of this hardness, leaving the part at the right temper to do its work best. And the *higher* the *tempering* heat, the *softer* the steel becomes.

There are various methods of drawing the temper of hardened parts or tools. The simplest is to heat the article in the forge or in a gas flame until the right color appears, then quench. Such a method is unreliable, however, due to the difficulty of heating evenly, so various methods are employed to overcome this difficulty.

Knowing, or having ascertained by tests, the exact temperature at which certain articles are to be drawn, many large shops now employ oil baths in which the heat can be controlled within very close limits. This is strictly a production process, and somewhat dangerous unless proper equipment is available. Precautions must be taken against the oil catching fire, and special receptacles with close covers are required to hold the oil. In practice, the oil is heated to the proper tempering heat, and the hardened parts dropped into it a length of time sufficient to impart to them the temperature of the oil They may be left in the oil to cool, or taken out to cool in the air. Quenching is unnecessary, as it is evident the parts can become no hotter than the bath into which they are dropped.

A simple and safe method that may be profitably employed in small shops is to heat the parts in a bath of melted lead, or lead, tin and other soft metals, or melted saltpeter. By referring to the Appendix

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the Table of melting points of various solids, some substance, or mixture may be adopted that will give the right drawing temperature. For example, a mixture of 8 parts lead and 4 parts tin has a melting point which will product in the steel immersed therein a pale or

straw yellow; 19 parts lead and 4 parts tin will produce a purple; 48 parts lead, 4 parts tin, gives a bright blue; 50 parts lead and 2 of tin, a deep blue. Melted saltpeter is excellent for tempering flat springs, and it gives them a nice finish at the same time.

The parts to be tempered must invariably be polished, so that the colors may be seen unless they are tempered in an oil bath, when colors are disregarded, and temperatures gauged by thermometer.

A simple, and very reliable method of tempering both flat and coiled springs has been evolved from the oil tempering process. It is known as "flashing" and consists of first hardening the spring in oil (usually sperm oil), then wiping off the surplus oil and heating the spring again until the small amount of oil remaining flashes and burns off. On thin springs one "flashing" is usually sufficient to draw the temper just right. When made of heavier stock, two or even three flashings may be needed.

Great difficulty is sometimes encountered in both the hardening and tempering of very small parts, such as pins, screws and very small drills; the method employed by watchmakers, for hardening watch drills, solves the problem. The drill (or other part) is heated in the flame of a candle to a good red heat, and instantly plunged into the candle grease. This, because the drill is so small that it cools in the air before it could be moved to a quenching bath. It may be flashed off to temper if desired.

Springs that have been "flashed" do not necessarily require quenching afterward, but no harm is done by quenching in the same oil in which they were hardened. Boiling linseed oil may also be used for tempering, but great care must be exercised in its use, as the temperature is so high the oil is likely to catch fire.

The sand bath is another effective method of tempering, but better adapted to the shop having a large furnace. However, small parts may be thus tempered by laying them on an inch layer of fine sand in a pan, and heating the pan in the forge, stirring the sand and parts together so as to heat evenly. Watch for the desired color, and quench the instant it appears.

A simple and often effective method of tempering small parts where even temper is desired, is to heat a good sized piece of iron red-hot, and lay the parts on it. This piece of iron should be supported over the quenching bath, so that the parts may be knocked off into it the instant the right color shows.

The following tempering liquids have been used in shops under varying conditions for different steels. Specific uses for the different formulas cannot well be laid down, as they were largely the result of experiment; but with the formulas available it is believed that the

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workman will find one or more of them to be adapted to his purpose:

1. Saltpeter, 1 oz.; borax, 1 oz.; sal ammoniac, ½ oz.; salt, 12 oz.; mix ingredients dry and dissolve in 1 gallon rainwater.
2. ½ oz. corrosive sublimate dissolved in 2 qt. soft water; add 1 handful of common salt. This solution gives both toughness and hardness. BE CAREFUL! *It is a deadly poison.*
3. 1 oz. saltpeter; 2 teaspoons pulverized alum; 1 teacup salt; dissolve in 2 gal. soft water. Do not heat above cherry red. *Draw no temper.*
4. Alum 6 oz. sal ammoniac 5 oz., saltpeter 6 oz.; dissolve in 5½ gal. water. *Draw no temper.*
5. Salt 1¼ pint; white vitriol 1 oz.; borax ½ oz.; saltpeter ½ oz. Dissolve in 2 gal. water.
6. Alum 1 oz.; saltpeter 1 oz.; sal ammoniac, 1 oz.; salt ¼ lb.; dissolve in 1½ gal. soft water. *Draw no temper.*

Those solutions which specify "draw no temper" are adapted to small blocky parts subject to much surface friction but little strain. When thus hardened and the temper drawn the parts show little or no wear after long usage. This treatment is also adapted to tools and parts made of steel with a rather low carbon content, which do not harden enough to stand drawing.

SPECIFIC INSTRUCTIONS FOR VARIOUS TOOLS AND SMALL PARTS. To the man who doesn't care to experiment and work out his own methods from the general instructions already given, the following methods, which I have used successfully, will perhaps prove acceptable. Note, however, that none of these methods are recommended as infallible—what will work for one man often fails for another.

Cast steel: Small quantity sal ammoniac in rainwater. Heat steel red, drop into water a second or two (according to size of part) remove, leaving enough heat to draw temper somewhat, then quench finally. If left in water the first time until cold, will be much too hard for any use.

Axes: Heat poll in charcoal fire to bright cherry red; change ends and heat bit cherry red, and dip bit only into cold salt water *immediately*. Polish sides of bit, then heat poll until edge of bit turns blue. Quench. Use no air blast.

Burglar and Drill Proof Temper: (Sometimes called "diamond chill") Heat steel bright cherry red and quench in 1 gal. urine, 1 oz. borax, 1 oz. salt. Do not draw.

Drills: 1. Heat drill and rub in potassium cyanide. Drill should be just hot enough to melt the cyanide. Heat drill to dark cherry red and cool in very strong brine, made with warm soft water. Will be hard and tough. Do not draw temper.

2. For drilling glass: Heat to low red, cool in strong solution of zinc chloride.

3. Heat drill cherry red, cool in strong brine; polish, and draw to light straw color.

Knife blades: Heat to cherry red between two straight pieces of bright red-hot iron; dip perpendicularly into raw linseed oil. Polish,

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and draw to light or medium straw color on hot iron; cool in linseed oil or weak brine.

Gun Hammers: Heat to cherry red in charcoal or lead bath, cool in linseed oil; polish and draw temper in lead or sand bath to yellowish brown, purple or blue.

Firing Pins: Same as for hammers, but draw to dark straw.

Extractors: Same as for shotgun main-springs.

Screw gauges: Heat to dull red in melted lead; harden in cold water or brine; polish bright, and draw to straw color in sand bath. This is a good method for any parts where it is important to reduce shrinkage to a minimum.

Cold Chisels: Heat in charcoal or coke fire (no blast) to dark cherry red, to a distance of two inches from point. Dip edge or point a distance of one inch, in clear salt water (1 qt. salt to 10 qts. water). Have ready coarse emery cloth wrapped around file, and quickly polish point and watch the colors run down from red spot. Dip entire chisel when point has color wanted (light purple for steel, dark purple for castiron).

Screw Drivers: Most ready-made screw drivers are made of poor steel—if you want good ones, make them yourself. Harden and temper in same manner as cold chisels, drawing temper at dark purple.

Springs: Shotgun main-springs. Heat to dull cherry red in lead bath, or charcoal fire, and quench in clear water with the chill taken off. Keep spring in water until it has temperature of water. Put spring in ladle or iron pan with equal parts lard oil and tallow, and heat pan until oil catches fire; turn springs about in flames until the oil on springs blazes freely when they are removed from flames. Lay them aside to cool without chilling.

Coil Springs: Heat to dull red and dip in linseed oil; flash off oil one, two or three times according to size of spring. Lay aside to cool. Revolver Springs (flat): Heat to cherry red, cool in linseed oil; flash off oil 3 times. Or, after hardening, polish springs and hold in melted saltpeter, (or Nitre Bluing Compound—see Chapter on Bluing and Browning) until dark blue. Remove to warm—not boiling—water.

Triggers, sears, etc. Harden and draw *point only* to dark straw.

Checking tools. Make them of drill rod. Coat working end with mixture used when hardening files; heat to cherry red, dip in linseed oil. Flash off once.

Chisels for woods: Same treatment as for checking tools; or, follow instructions for cold chisels, quenching in water when cutting edge is light straw color.

Parts subject to friction only: Parts requiring great hardness to resist wear, and which are subject to but little danger of breakage from strain or percussion, may be hardened at dull cherry red without drawing. To relieve internal strains however, a slight tempering is usually advisable, particularly in the better grades of steel.

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Heating in sand bath or melted lead to a *very* pale straw—scarcely any color at all—will add strength without noticeably decreasing wearing qualities. Quench in oil, or water with the chill taken off.

TREATING ACTION PARTS OF HIGH POWER RIFLES: The man not specially trained and experienced in the heat treatment of rifle actions has a mistaken sense of his abilities, and is courting disaster—perhaps death, when he attempts to temp-

er with the hardening of Springfield, Krag, Mauser, or other modern bolt actions designed to handle ammunition developing over 40,000 pounds pressure. The best advice that can be given is "LET THEM ALONE" Failure, due to ignorance of the composition of action parts, and lack of knowledge and the expensive equipment needed, is sure to follow such attempts. The splendid work of Springfield Armory and of the large arms plants cannot be improved upon by the amateur or the professional gunsmith—nor even by the larger machine shops more or less familiar with hardening and tempering. There have been too many blown up rifles to warrant any man taking unnecessary chances, and when one considers the all too frequent propensity of handloaders to seek velocities higher than standard, there comes a feeling that the maximum strength developed by the foremost experts is not too much for the arms we are to shoot.

For this reason, the writer always tries to discourage the desire of a rifleman to have the position of his bolt handle altered, or any other alteration that might affect the original hardening. If a bolt handle must be bent, protect the bolt, and particularly the end carrying the lugs, with wet rags, as described in another chapter.

I once saw a man who claimed to be an expert, and whose reputation was national, attempt to harden a Mannlicher bolt by heating to nearly white heat in cyanide and quenching in ice-cold salt water. The owner of the gun could have thanked his stars that it broke in half instead of merely cracking, and letting loose in his face at some later date.

A good many Mauser actions are imported into this country in the white, and sold to private makers who fit them with special barrels and stocks. Purchasers of such arms are sometimes disconcerted to find the receiver so soft it can be scratched and nicked with a penknife. Why?—simply because the maker—perhaps assembler would be better—had neither the means nor the knowledge required for properly heat treating it. These actions are sold soft, in most cases. If not soft when purchased, they are usually annealed, so that they can be engraved. I have seen not one, but dozens of rifles come in from the engraver and immediately turned over to the bluing man, without any pretense of heat treatment.

In the case of Mauser actions these guns are probably safe to shoot, for the steel is of high quality, and designed for strength.

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With modern loads they will undoubtedly stretch and develop excessive headspace in time; yet I should much prefer an action not hardened, to one hardened by some bungler who didn't know his stuff.

Many a good Springfield,—and many another good action as well—has been ruined in the "dolling up" process. Good engraving is certainly to be admired on a high grade arm; but bear in mind that engravers cannot perform miracles. Before making a single cut on a receiver it must be thoroughly annealed, and if the rifle is to give satisfactory service, must be subsequently rehardened. The man who contemplates purchase of a beautifully decorated arm will do well, therefore, to make sure who is to do the engraving, and whether he is capable of annealing the action without damage to the steel; and further, whether it will be re-hardened, afterward, by whom, and how. The ordinary case-hardening methods used so successfully on machinery steel are not adapted to the steel used in rifle actions—and may result in ruining them. Yet such methods have often been employed to give the gun owner a false impression that his arm had received the necessary hardening treatment.

If a gunsmith objected or hesitated about giving full and complete information on these points I should feel warranted in assuming that he had something to conceal. And unless his claims of ability along these lines could be fully verified by recognized authorities, I wouldn't trust his guns outside the showcase. I have but one face to give to my country!

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Chapter 22

CASE-HARDENING

ALTHOUGH many believe that the use of machinery steel for cutting tools is of comparatively recent origin, yet such is not the case. There seems to be good evidence of the use of Case-Hardening, or Cementation in China during the eighth century; and Brearly in his book "The Case Hardening of Steel" refers to a book written by Theophilus Presbyter, a Benedictine monk, in the latter part of the thirteenth century, giving instructions for case-hardening files. His method was so similar to many in use today, that one is surprised at the apparent lack of progress in the fundamentals.

Even today, files made of mild Bessemer steel are still in common use in certain parts of Europe, particularly Russia; and these are capable of doing excellent work.

For many uses in gunsmithing the use of soft machinery steel is to be commended. When properly case-hardened the surface resists wear even better than tempered tool steel; while the soft, tough metal inside gives strength.

Before going into the processes employed it will be necessary to understand just what case-hardening is, the principles, and the effect on the steel. Cementation, the technical term for case-hardening, implies the addition of substances into the surface of the metal which changes its structural formation, cementing or binding the fibres into a finer grained mass with the hardening properties of steel. And in fact, the surface of the metal is actually changed into steel, the thickness of this skin varying from a few thousandths up to a sixteenth or even an eighth of an inch.

Mechanics will argue that once a piece of case-hardened iron is heated the hardening is destroyed. But such is not necessarily the case. Due to the thinness of the skin, it is easy to burn out the carbon; yet by careful handling a case-hardened surface may be an-

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nealed, rehardened, and even the temper drawn somewhat. Further, it is possible, and often practicable, to produce cementation (develop an outer skin of steel) without hardening it in the process; after which it may be hardened and tempered the same as tool steel.

Briefly described, therefore, case-hardening or cementation consists of combining carbon with iron or machinery steel by heating the two substances together; and for some reason which the author does not pretend to know, the use of some form of animal charcoal as the carbonizing agent is deemed preferable, if not absolutely essential in most processes; although wood charcoal is used in some. In addition to the form of charcoal used—charred wood, horn, hoofs, bone, hair, leather—there are numerous other substances named in carburizing mixtures, as sodium carbonate, common salt, saltpeter, rosin, raw bone, flour, soot, sawdust, hair, vegetable fibre, potassium bichromate, ferrocyanide, limestone, seed husks, etc. Probably—and quite possibly—not all of these ingredients have any particular value; while others are too costly to make their use at all practical, particularly in the small shop.

There are on the market numerous carburizing mixtures, or case-hardening compounds under trade names and secret formulas. Generally speaking, we do not favor their use. They are not noticeably superior to standard mixtures, formulas for which appear in several authoritive handbooks; they cost more, and, should they fail to do their work properly, the operator is totally in the dark as to the cause.

There is no mystery about case-hardening. Having learned its principles one can by a little experiment evolve mixtures and processes best adapted to his purpose—and having done so, stick to those mixtures with reasonable certainty of uniform results.

The essentials of a good carburizer are: porosity, so that the gases released may move freely through and around the parts being treated; ability to evolve carburizing gases at the heat required for cementation; compactness, and freedom from shrinkage, so that parts may not be left unsupported, to bend or warp in the hardening box; and good heat conductivity, so that the work in the box may be of uniform temperature.

CASE-HARDENING EQUIPMENT. Hardening boxes will vary in sizes from a few inches up to two or three feet; they are usually oblong in shape, and made of cast iron, though sometimes a mild steel box is required, as will be mentioned later. As most gunsmiths need equipment only for hardening small parts, boxes eight or ten inches long by five or six inches in width and depth will probably answer all purposes. The walls need be only about 1/4 inch in thickness. Wooden pattern boxes may be made up, as any pattern is made, and sent to the nearest foundry for casting. Each box should have a cast iron lid, which fits loosely, and which in operation is cemented in place with fire clay. And, if the process requires that

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the box be dumped into water or a solution, there should be rings cast on ends or sides so that it may be handled readily with iron hooks on removing from the furnace. Iron and steel hardening and annealing boxes are also offered by several manufacturers, and any large hardware jobber or machinist's supply house can arrange to obtain them in the sizes required.

Despite the increasing use of electric furnaces, many hardeners still prefer gas blast furnaces, of which several excellent ones are made in this country, specially designed for hardening, tempering, annealing and case-hardening, as well as special oil tempering furnaces for production work. They too can be obtained through any dealer in machine shop supplies. Furnaces of this type, are small and compact, and simple, once their operation is mastered. Yet, while ideal for the larger shops, their cost, and cost of operation is prohibitive in the smaller ones.

We will, nevertheless, describe several processes involving the use of gas furnaces, as well as simpler processes adapted to the occasional job, and calling for no more costly equipment than a small forge, or even a gas burner.

A good *outfit for fine grain* case-hardening consists of a good hardening furnace or oven, the required number of iron boxes, a good supply of granulated raw bone, a similar supply of granulated charcoal, a quantity of hydro-carbonated bone and a quantity of charred leather. Hardening materials are usually sold by the manufacturers of hardening furnaces, or of patent hardening boxes, through the supply dealer or jobber. Bulk single ingredients are preferable to secret compounds. Charred bone may be produced by putting the granulated raw bone into one of the boxes, covering tightly, and placing in the furnace at the end of the day's work when the fire is allowed to die. The object is simply to char the bone thoroughly without burning it. Charred leather, also called for in some work, may be prepared in a similar manner. Use thick leather, like saddle skirting or shoe sole scrap, obtainable at any leather house. The leather should be thoroughly charred and crisp, so that it may be pounded to a fine powder before using.

In addition to the foregoing a tank or barrel must be supplied for quenching the work, and a smaller tank with steam coil so that water in it may be heated to any desired temperature, and a bath of raw linseed oil.

For very fine grain case-hardening, use only charcoal, granulated raw bone, hydro-carbonated bone and charred leather, for the first heat. Bring to cherry red heat and hold at that temperature for two to four hours, depending on size of work. Leave box in oven to cool slowly. This "cements" or forms a steel outer skin on the work, leaving the grain open. When the work has become cool, unpack and heat the parts to red heat in molten lead, and quench in oil, same as in hardening tool steel. Then repack in box, using

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only granulated charcoal, and bring to a dull red heat. Remove from oven, open box, and dump contents instantly into water with the chill taken off. This treatment brings out a dense, tough, close-grained and very hard surface, and the parts will be much stronger than if made of tool steel

Note: When dumping parts into water, carry the box very close to the surface of water, so that parts are quenched in water without the air striking them. This applies to all methods of case-hardening.

CASE-HARDENING WITHOUT COLOR: The foregoing process may or may not result in some color, but cannot be depended upon to produce the brilliant colors often desired. A method that produces no color, but gives a hard, even grained surface, follows:

In the bottom of box place a layer of granulated raw bone 1/2 inch deep; on this arrange the parts to be hardened, then another layer of bone, and so on to within an inch or so of the top. Then fill up with old bone that has been used before. Put on cover and seal with fire clay. Heat to good cherry red three to four hours, then dump in clean cool soft water. Very small or thin pieces should be dumped in oil. This results in good even hardening, and the parts come out a clean steel gray, free from scale.

-CASE-HARDENING MALLEABLE IRON: Buttplates, pistol grip caps, and many other parts not essential to the mechanism of a gun may be made of malleable iron castings. If they are *completely* annealed in the making, they may be successfully case-hardened—otherwise results are doubtful.

For this work use one part granulated raw bone, well mixed with three parts granulated charcoal. For Bessemer steel or very small parts, slightly reduce the proportion of bone. Pack in boxes or parts as previously described, sprinkle charcoal dust over the top, and heat to cherry red two to four hours. Dump in clean soft water.

CASE-HARDENING WITH COLORS: This involves the use of charred bone, prepared as previously described. It is essential that the parts be well polished—the better the polish, the more brilliant the colors. Burnishing and buffing is not advised, as it closes and fills the pores and retards the process. Polish the parts with fine abrasives as described in chapter on polishing, and clean by boiling in lye solution as for bluing, or by pickling; after cleaning, handle the parts only with clean, white cotton gloves that have been washed and boiled. A single touch with the bare finger will leave a spot that will mar the fina. finish.

Pack the work in layers as before, having the layers of charred bone about 3/4 inch deep, leaving about 2 inches at top which is filled with charred bone. Put on lid and seal with fire clay. Be sure that none of the parts are nearer than 1/2 inch from sides of box, and that the parts do not touch each other. Bring the box to a nice cherry red and hold uniform at this heat two to four hours. *Too high a heat will result in no color.*

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The quenching bath should be clean, cool *soft* water. Arrange a wire mesh screen six or eight inches below the surface, and from bottom of tank bring up a pipe connected with an air pump, so that a strong jet of air may be injected while dumping. If possible, also have a supply pipe carrying fresh water in near the bottom, with an overflow pipe near the top, to keep the water at uniform temperature. Hold the box almost at the surface of water and dump quickly. The wire mesh catches the parts while the bone drops through into the tank.

If the parts are small and few in number, a simpler method may be improvised by having an assistant stir the water vigorously with a paddle while dumping. It is the air bubbles in the agitated water that gives the fine mottled effect so much admired.

When cool the work should be taken out and boiled in clean soft water, dried in sawdust, and oiled or lacquered.

HOWE'S METHOD: Mr. James V. Howe is responsible for the following method which we have tried only once, but with very good success. The hardening, however does not extend very deeply, although the colors were very good.

Into a cast iron pot or box large enough for the parts to be colored, place a quantity of potassium cyanide and melt in a forge with air blast. *Due to the poisonous fumes of the cyanide, great care must be exercised*—use a portable forge outdoors, or see that there is a hood to carry off the vapors. Otherwise, one sniff may mean *taps*. Place the work to be colored into the melted cyanide, and bring to cherry red. Hold at this heat for ten to fifteen minutes. Remove work and quench instantly in a solution of 2 quarts water, 3 ounces saltpeter, and 1 ounce gunoil. Stir this solution vigorously while quenching.

AUTHOR'S EXPERIMENT: To ascertain just what the home gun tinkerer might hope to accomplish with limited equipment, the following experiment was made: A quantity of powdered leather (shoe sole grindings from a shoe repair shop) was obtained and charred over a gas burner, spreading out a thin layer on a tin pan. Some bone meal from a poultry supply house was charred in a like manner. These materials were conveniently arranged with some willow charcoal from the drugstore, and some powdered potassium cyanide, sodium nitrate, potassium nitrate, and common salt, each on a separate pan. The work, (an old Stevens Favorite receiver that had been polished and cleaned) was held on a rod bent like tongs, with the two ends inserted into the barrel ring, so that the receiver could be turned either side up, and then heated over an ordinary gas plate. I could just get a cherry red by turning the burner up as high as possible, and had no difficulty in keeping the heat uniform. At this heat the receiver was removed from the fire for a moment, while I quickly dropped on it some cyanide, sprinkling it unevenly in spots with a small spoon. This was fol-

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lowed by similar applications of the saltpeter, the salt charred leather and charred bone in no particular order. I just worked as rapidly as possible, and as soon as one material was melted I dropped

on another. I continued this for perhaps twenty or twenty-five minutes, keeping the receiver red hot and in the fire all the time except when actually applying the materials. I then quenched it in a solution of a gallon of water and a half pint of linseed oil which was kept vigorously agitated by means of a tire pump with long tube reaching to bottom of bucket.

Just which of the above materials was responsible, or whether it was the combination of all, I do not know; but I did get a very attractive job of coloring, although the hardening was not as deep as I wanted—just a few thousandths. The coloring was generally darker than I wanted, with more blue than was necessary. The red was brilliant—this I believe to be due to the salt used. Perhaps reducing the amount of saltpeter, and eliminating the willow charcoal would have resulted in more yellow and less blue, but up to this writing have had no time for further trial.

I am not recommending this as a fixed process, but it does seem to hold possibilities for the occasional job, particularly on some small caliber arms where strength and extreme hardness are not primarily essential.

CYANIDE HARDENING: It must be remembered that, generally speaking, the use of potassium cyanide is not considered as good practice as the use of animal charcoals. Yet it offers an easy means of achieving very fair results with little or no equipment.

Quite often small tools such as drift, prick and center punches, will prove to be made of such low carbon steel that they will not harden by ordinary means. It is a simple matter to heat them red hot in gas burner or blowtorch, dip them in powdered cyanide and reheat—repeating two or three times—and finally quenching in clear water or brine. Tools, and parts of gun mechanisms so hardened will do their work. Often in working down a trigger pull the sear and hammer both prove so soft that the pull will not remain. This method of hardening saves the day. It is also applicable to screwdrivers—and one can quickly make up a number of these for various sized screws from ordinary coldrolled steel, and harden them so that they will give good service for months. Such screwdrivers will better stand the strain of loosening tight screws than if made of tool steel, with its constant danger of snapping off the point, and possibly marring the gun.

Cyanide hardening should never, under any circumstances, be used on the bolt or receiver of any high power rifle.

COLORING WITHOUT HARDENING: Heating small parts to red heat in cyanide melted in a cast iron pot or crucible and quenching in water under proper conditions produces both hardness and colors. When hardening is not desired, the colors only can be

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obtained by the same process, but by substituting a mild steel pot for the cast iron one. Have the pot made by riveting and welding, as shown in Figure 127. Heat the parts in cyanide melted therein, and quench in water that is being agitated, as before described. The first time such a pot is used the parts will come out as hard as though treated in a cast iron pot—but parts heated in it thereafter will come out soft, but colored. Therefore, if coloring only is wanted, the pot should be heated for a half hour before putting in the cyanide.

Cyanide hardening is, in the final analysis, merely a substitute for the more satisfactory, but more expensive and difficult processes using charred bone and leather. Yet it is often the only process readily

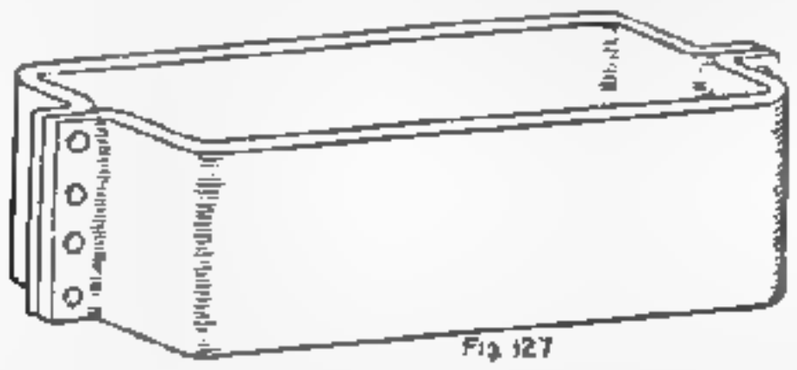

Fig. 127

available in the small shop, and if extremely deep hardening is not essential, is quite satisfactory. *But be careful.* Avoid putting articles into melted cyanide with any moisture on them—it will sputter and fly like melted lead. I have seen a dog die almost instantly when half a grain of cyanide was dropped into his eye. A photo-engraver accidently took a drink of water from a glass that had a few drops of cyanide solution in it. He started to walk out of the developing room—and fell dead with his foot in mid air and the glass in his hand.

SOME HARDENING KINKS: For drilling glass, chilled iron, hardened steel, etc.,—a Springfield receiver, for example—take a new drill that is well sharpened and has never been heated to cherry red. Dissolve zinc in muriatic acid to saturation, then add an equal quantity of water. Heat drill to dull cherry red and quench instantly in this solution, until cool. Use drill without further sharpening. Wet the drill point with turpentine when drilling very hard steel or glass.

Small drills may be made of any piece of steel wire, by filing to shape. Mix 4 parts powdered rosin, 2 parts fish oil and 1 part tallow, heated together to melting point. Heat drill to dull red and dip into mixture, leaving it until cool. Reheat to red, and quench in cold water. Repeat two or three times, and the drill will easily cut glass.

A short piece of cast iron pipe, with ends threaded for caps, sometimes makes a handy substitute for cast iron box for case-hardening

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small parts. Weld an iron rod to the center for holding while removing from fire, and use very short threads on ends; notch caps, and make a special spanner so that both caps may be removed instantly. Hold one end almost touching water, and push out contents with an iron bar.

Yellow prussiate of potash is sometimes substituted for potassium cyanide with excellent results in hardening small articles; also a mixture of prussiate of potash, sal ammoniac and salt. Some mechanics use a mixture of prussiate of potash and black loam, mixed to a paste with water and spread on the work When dry, heat to red heat and quench in salt water.

When hardening steel (low grade) by case-hardening, avoid the use of raw bone; the phosphorus it contains will make the steel brittle.

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CHAPTER 23

SOLDERING, BRAZING AND WELDING

THE art of joining metals together by soldering, brazing or welding is well known in a general way, yet comparatively few become proficient in either of the three named processes. And since all three are of importance in the field of gunsmithing this chapter is devoted to the clearing up of some of the difficulties surrounding the subject.

While reasonable experience is the greatest aid to soldering, nevertheless the rankest amateur can do a splendid job once he is given an understanding of the principles involved, which are simple and few.

Brazing is more difficult, usually requiring some special equipment, but it also can be mastered with a little time and patience. Welding, on the other hand, is a specialty trade and like other trades must be mastered thoroughly. It requires special and expensive equipment, and most gun shops—even the larger ones—usually find it desirable to send their welding out to a shop doing this work exclusively. Our discussion of welding, therefore, is intended principally to aid the gunsmith or home worker to lay down intelligent specifications on the work for best results.

SOFT SOLDERING, OR SOLDERING, as it is usually called, is the simple process of uniting two pieces of metal by means of an alloy having a relatively low melting point. The beginner's most common difficulty lies in making the solder "stick." Instead of flowing and taking hold on the metal, it forms little balls which roll off the work as fast as it is melted. In a good job the solder is spread or "flowed" evenly over the work, and when so applied its holding strength is surprising. Brass, copper, zinc, tin, sheetiron, iron, and steel, are readily soldered with suitable alloys and fluxes, and while the solder joint, due to greater softness, will not be as

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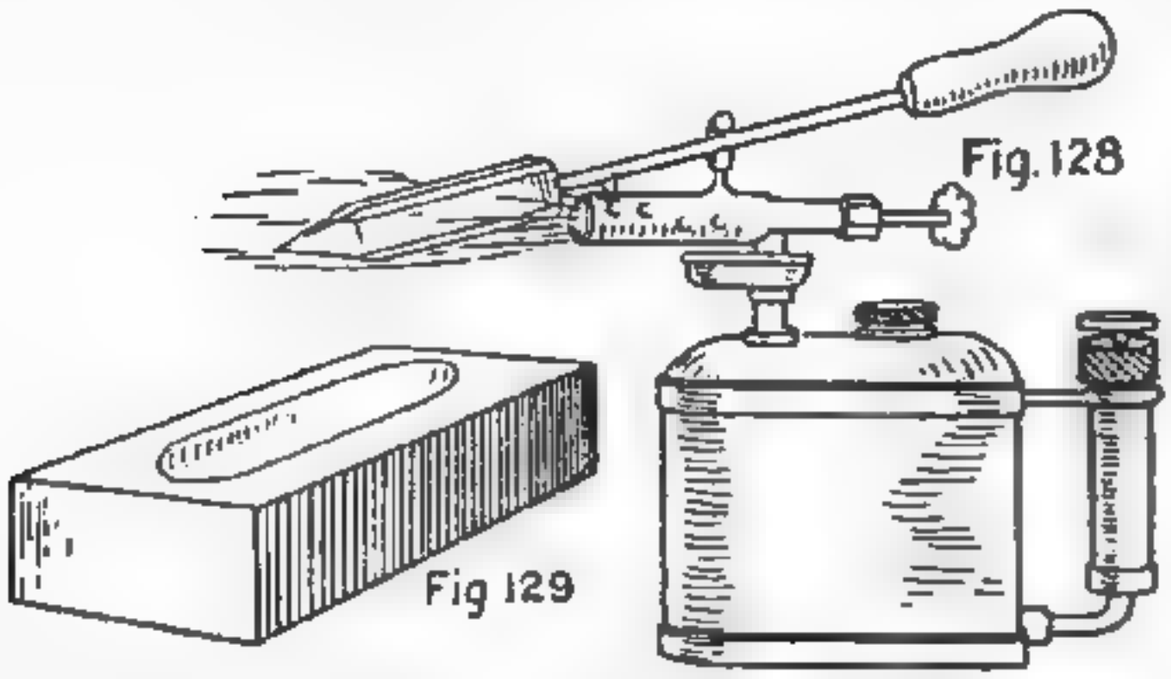
strong as the metals joined, it will nevertheless resist any normal strain it is likely to receive, and will "stay put" until the solder is removed by melting.

In soft soldering two principle methods are in common use. The first involves the flowing in of the solder between the metals to be joined by means of a heated soldering copper; the second, and more

useful method for the gunsmith, is known as "sweating," or "sweat soldering." In sweating, a thin coating of solder is applied to the two surfaces to be joined, which should be fitted very closely. These



surfaces are then brought together, usually under pressure, and the whole assembly heated until the solder is thoroughly melted

All things being equal, the sweated joint is much the stronger of the two; for in heating up the parts being joined the pores are opened and the solder, which is heated well beyond its normal melting point, penetrates the surfaces for a short distance. Such a joint is nearly as strong as a brazed joint.

The equipment required for soft soldering are: a gasoline blowtorch, gas heater, plumber's gasoline furnace, or other suitable means of heat; a soldering "copper" of good size (from one to two pounds weight); a knife, file, or scraper for cleaning off the surfaces to be joined; a quantity of suitable solder; and a "flux" to prevent oxidation of the surfaces while they are being joined. Figure 128 shows a gasoline blowtorch and soldering copper of practical design. For ordinary soft soldering, however, a common gas burner will heat the copper very satisfactorily.

Of all equipment for this work, the shape and condition of the copper is most important. The point should be filed very sharp, with clean, square edges, and the point well tinned. By "tinning" is meant the coating of the point with solder so that it will pick

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up the metal and carry it to the work. There are several good methods of tinning the point. One is to chip out a hollow in a soft yellow brick, as shown in Figure 129; melt some rosin and pour it into this cavity, along with a small quantity of melted solder. Heat the copper until solder touched to its point will melt quickly, and then press it into the rosin and solder in the brick. Stroke it back and forth a dozen or so times, turning it so that all surfaces are rubbed against the brick. This abrasion cleans the point, the rosin fluxes it, and the solder adheres, forming an even coating all over the point for half an inch or so back. Keep this tinning brick handy at all times—it is a reminder to you to tin the copper well before every job.

Overheating the copper must be avoided. Too much heat will burn the metal and destroy its efficiency. Just a few degrees above the melting point of the solder used is hot enough. You can tell when the copper is overheated by the appearance of the tinned point, which will take on a dull, partially corroded appearance, showing that the tinning has burned in. When this occurs, file the point clean and retin—and be more careful next time. Continued overheating will ultimately ruin the copper.

Another method of tinning which I like better, but which must be used with discretion, is to merely rub the point of the heated soldering copper on a large piece of sal ammoniac, then rub it on a bar of solder, alternating until the point is well coated with solder. This method is quick and sure, the sal ammoniac cleaning the point instantly. The fumes and vapor from the sal ammoniac, however, are very conducive to rust, and this operation must be performed away from tools and guns, and in good ventilation. Otherwise, every bit of steel will be found covered with thick rust within twelve hours.

After the copper, the flux comes next in importance. A metal surface that has been oxidized cannot be soldered, and flux is used to retard oxidation until the solder has taken hold. Despite the

many soldering fluxes on the market, common rosin, one of the oldest fluxes in use, remains one of the best. It is used by merely grinding or pounding up the chunks as they come from the dealer, and may be applied with a wool brush made like Figure 130, by forcing a bunch of wool yarn into a small piece of brass tubing and pinching the end together. Despite the almost universal usefulness of rosin, there are other fluxes better adapted to certain metals, as

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shown by the following table taken from "Soldering and Brazing" by Raymond F. Yates:

Metal	Flux
Bismuth	Zinc Chloride
Silver	Zinc Chloride
Gold	Zinc Chloride
[illegible]	Hydrochloric Acid (Muriatic)
Pewter	Gallipoli Oil
[illegible]	Ammonium Chloride
Galvanized Steel	Hydrochloric Acid
[illegible]	Rosin or Zinc Chloride
Lead	Tallow or Rosin
Tin	Zinc Chloride or Rosin
Gun Metal	Ammonium Chloride or Zinc Chloride
Copper	Ammonium Chloride or Zinc Chloride
Brass	Ammonium Chloride or Zinc Chloride

To make zinc chloride, drop a few pieces of scrap zinc into a wide mouthed bottle of hydrochloric (muriatic) acid. The acid will fume and boil as the zinc is eaten up by it. When it will dissolve no more zinc, and all action has subsided, it is ready for use. Apply with a small brush—the stiff bristled brush in a tin handle that comes with a bottle of mucilage is just the ticket.

Ammonium chloride is the same as sal ammoniac, and may be purchased in powdered form at any drug store. It is applied with a brush like powdered rosin.

Some fluxes, if used on copper, will cause an objectionable after-corrosion. Plain rosin is very good for soldering copper, or the following will be found satisfactory:

Zinc Chloride crystals	41 parts (by weight)
Alcohol	33 parts (by weight)
Glycerine	33 parts (by weight)

Dissolve the zinc chloride crystals in the alcohol, then add the glycerine. Apply with a brush in the usual manner.

Having a suitable copper and method of heating it, the next consideration is the solder itself. The common soft solder sold in hardware stores is composed of lead and tin in varying proportions. Lead and tin solders will answer for most uses in the gunsmithing trade, nevertheless there are times when a solder of lower melting point is desired, and this usually means a lead and tin solder to which Bismuth has been added to reduce the melting point. The following tables* give the melting points and percentages of various lead-tin, and lead-tin-bismuth solders to read—giving the melting point and percentages:

LEAD-TIN SOLDERS

Lead	100	90	80	70	60	50	40	30	20	10	0
Tin	0	10	20	30	40	50	60	70	80	90	100
Melting Point, Fahr.	619	563	519	504	464	421	374	365	393	421	450

LEAD-TIN-BISMUTH SOLDERS

Lead	32.0	25.8	25.0	42.8	32.5	10.7	50.0	35.8	10.0	70.8
Tin	16.5	19.8	16.0	14.8	32.5	32.1	31.0	52.1	80.0	9.1
Bismuth	52.5	54.4	59.0	42.0	32.5	56.2	17.0	12.1	10.0	20.0
Melting Point, Fahr.	205	214	257	253	293	293	253	358	360	453

* "Modern Welding Methods" by Victor W. Page.

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By studying the percentages in the above tables the gunsmith can prepare a solder that will melt at any desired temperature. Thus, a solder composed of lead, 32 parts; tin, 15.5 parts; and bismuth 52.5 parts will melt in boiling water, the temperature of which is 221 degrees. Parts soldered with such a mixture could not be blued, as the bluing heat would melt the solder. Such an alloy, however, could be used to attach parts already blued where it was desired not to damage the finish by heat—just gently warming over a mild heat would do the trick. There is little danger of damaging either the finish or the physical properties of the steel, however, at tempera-

tures below 300 degrees, so one of the alloys having a somewhat higher melting point would usually be selected because of their greater strength. Generally speaking, softness and weakness and low melting points go together, and vice versa; yet even the softest solders are surprisingly strong, and serve admirably for attaching barrel bands and similar work where the solder itself does not have to hold all the strain.

In ordinary soft soldering, the parts are usually clamped or wired into position after the contact surfaces have been scraped or filed bright. The proper flux is then applied, and the heated soldering copper rubbed on the bar of solder, which picks up a drop of the molten metal. This is applied to the joint being formed, and flowed well into it at all points. When wire solder is used, the end of the wire and point of soldering copper are brought together at the point being joined, and the solder melted and flowed in.

Wire solder is very convenient and may be had either solid, or hollow, the core containing either powdered rosin or an "acid" flux. I have found this "acid-core" wire solder perfectly adapted to 90 per cent. of all gun work. It flows and adheres perfectly on steel, and is both convenient and economical to use. Moreover, when solder was not handy, I have used pure block tin on steel with entire success, fluxing either with powdered sal ammoniac or rosin.

SWEATING: But the uses of common soft soldering in gunsmithing are relatively few. Broken parts cannot be repaired by this method, for the solder will not stand the strain. Sweating has far more use in gunsmithing than almost any other means of joining metals. By this process the barrels of double guns are joined together, and ribs attached; sight ramps are affixed to rifle barrels; swivel bands, forend screw bands, rear sight bases are firmly and accurately attached, and many other jobs readily accomplished that would not be possible by any other method.

One of the advantages of sweating lies in the low heat required to melt soft solder. The liability of damage to barrel or action is practically nil at temperatures below 500 degrees, and as all soft solders melt below this temperature, they suggest themselves as a logical medium.

The equipment for sweating is simple, including only a blowtorch,

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a file or scraper for cleaning the parts, suitable soft solder, flux, and in some cases small clamps for holding the work together. A piece of felt or woolen rag will also be needed for wiping. The soldering copper is seldom needed, although occasionally it may come handy, while a gas burner may replace the blowtorch on many jobs.

A description of my own method of sweating on a barrel band and sight ramp will include details applying to many similar jobs. After the band and ramp have been finished and fitted as described in Chapter 24, their respective locations should be marked on the barrel. Assuming that we are attaching a band for quick detachable sling swivels, mark with a scriber a light line on bottom of barrel at its exact center, and a center line on the swivel stud of the band. Slip the band on the barrel and note its position. Now at this point the barrel is to be cross-polished with medium coarse emery cloth until bright and clean. Heat barrel at this point until hot enough to melt solder. Apply flux, then the solder, rubbing it clear round the barrel until the spot is well tinned. Re-heat the barrel slightly so that solder is in a melted state, then with the woolen rag or felt folded in the band, quickly wipe the excess solder off. If you use acid-core wire solder, no fluxing is necessary—just rub the solder on the heated barrel. Wiping off the excess leaves the barrel tinned only at the point where band is to be fitted—a coating of no perceptible thickness.

Now lay the barrel aside while you tin the inside of band. With an old knife blade, or scraper made of a file or hacksaw blade, scrape the inside of band bright and clean. Be careful not to scrape the extreme edges, or there will be gaps where the solder will show. Hold the band in tongs or pliers, heat it until it will melt the solder, then apply solder all over the inside—first using flux unless you have a self fluxing solder. Apply the solder thickly, and be sure it flows well over the inside. (In holding the band with tongs or pliers, do not make a mistake of holding it above the band, or the melted solder will run down on hand or wrist, giving a bad burn). When the inside is well tinned, reheat until solder is melted, throw out the excess with a quick shake, and "wipe" the inside with a pine splinter that is rich in rosin.

Now clamp the barrel bottom side up in the vise. The barrel will be pretty well cooled off, while the band is still hot. Slip the band into position, or as near to position as it will go. With the torch heat both band and tinned spot on barrel together until the coating of solder is in a melted state, then with a piece of brass or copper tap the band to place, so that the center lines you previously marked on band and barrel coincide. If the band goes on slightly out of line, a little additional heating will permit of the swivel stud being tapped a trifle to right or left as required.

Chances are that the heat of the barrel will have kept the solder melted during this fitting in place. If not, heat again until you are

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sure the solder is all melted, then tap the band back a sixteenth inch or so to assure a snug fit, and allow to cool.

Next comes the ramp. Slip it on the barrel, and with a sharp scriber mark around the lower edge of the rib where it rests on barrel also mark around rear edge of band. Remove ramp, and file or scrape the barrel lightly within these marks, using care not to take off enough metal to make the ramp fit loosely. Tin the barrel within these lines, and wipe off excess solder as before, then tin the entire inside of barrel ring and concave bottom edge of rib, wiping off excess with a pine splinter. Set barrel right side up in vise, warm ramp to expand it, and slip over barrel, tapping it to

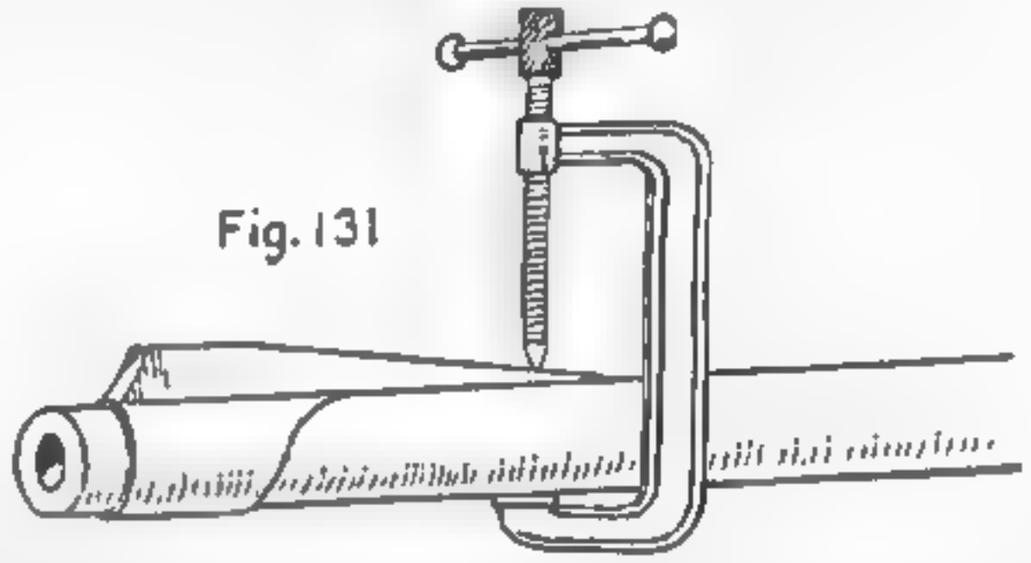

Fig. 131

position with a piece of brass or copper. Line it up carefully by setting the barrel and action temporarily into the stock and looking through the rear sight. Regardless of whether a special fixture might show the ramp to be upright or leaning, you would never be satisfied unless it *looked* straight to you; so I find that this eye method is perfectly satisfactory. A good test is this: if the ramp seems to lean a trifle to the right one time, then a trifle to the left next time, it is almost sure to be perfectly upright on the barrel; while if the eye shows it leaning the same way each time you look at it, you can believe your eye. Heat it sufficiently to melt the solder (no danger of its running out and spoiling the joint) and tap it in the direction required. Then set a small clamp on the rear end of the rib to hold it firmly to the barrel, and let cool. (Figure 131). When cool you are ready to remove the excess solder and repolish barrel for bluing, as described in Chapter 18.

SWEATING SCOPE BLOCKS: Scope blocks and mounts may be sweated in a similar manner except that it is not necessary to mar the finish. With the blocks or mounts located and temporarily screwed into position, mark around their edges with a scriber, then remove them and carefully file or scrape barrel or receiver, keeping well inside of the outline. Scrape underside of blocks and

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tin them, also tin the bright spot on barrel, but instead of heating up the barrel in this instance, use the soldering copper and apply as thin a coat of solder as possible right on the spot. Quickly wipe off the excess with a woolen cloth or felt, and if a small quantity of solder gets on the blued portion it will not stick, but may be quickly brushed off. Fit the mounts back into position, set in the screws moderately tight, then lay the heated soldering copper on top of blocks and hold there until you see the melted solder running out of the edges. Quickly tighten up the screws, which being hot, will shrink in cooling, and together with the solder will hold the blocks until a certain oft mentioned locality freezes over. Wipe the excess solder from around the edges before it hardens, and the job will be perfect. This method of sweating may be used successfully with Griffin and Howe or Noske scope mounts on bolt action rifles, in addition to the pins and screws. (See Chapter 29.)

Swivels which attach to the barrel, but do not have the encircling band, such as are seen on many foreign rifles, may be sweated into position in the same manner without marring the rest of the barrel, although, having no screws to hold them in position, they must be clamped very accurately. On such swivels it is advisable to drill one or two small holes (about 1/16") into base of swivel, and drill corresponding holes from 1/32" to 1/16" into the barrel. Tight fitting pins are then made of drill rod and driven into the swivel base, where they serve as guides in locating the swivel into position before clamping. The pins, short as they are, also serve to take much of the strain from the solder joint.

Another and one of the most important uses of sweating is in the joining of shotgun barrels, and of attaching the ribs between the barrels. This is described in detail in Chapter 31.

BRAZING, sometimes called hard soldering, is indicated for joints that must withstand considerable mechanical strain. The use of brazing is limited in gunwork by reason of the high heat to which the parts must be subjected. This eliminates it pretty largely for attaching sight bases or other parts to barrels, for, while the bore may be protected against scale formation as will be explained later, there is always danger of causing the barrel to take a permanent bend.

Although the terms hard soldering and brazing are often used interchangeably, there is this difference; hard soldering employs a silver-brass alloy usually placed between the parts to be joined, which are then heated together; while brazing is really a process of uniting two surfaces by means of spelter, or by flowing in molten brass.

Silver solder is a mixture of pure silver and brazing spelter in various proportions, the percentage of each determining the melting point. Thus alloys can be produced with melting points from 700 to 2000 degrees Fahrenheit. And of course the higher the melting point the stronger the job. The best silver solder for the gunsmith

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to use is that made in a thin ribbon, used primarily for joining the ends of bandsaws. It can be melted with a common gasoline blowtorch provided the parts being joined are not too large, although an oxy-acetylene torch with the flame properly regulated, is more desirable for all work.

In addition to a suitable source of heat, you will require a pickle bath of one part sulphuric acid with 20 parts of water; a quantity of borax for fluxing; a block of charcoal on which to rest the work (this serves to return the heat to the work and greatly facilitates matters); a piece of slate and a short wire for handling the borax, and a can of clean water with a small brush completes the outfit.

When joining two parts together, as, for example, a bandless sight ramp to a barrel, or the grip-safety extension for .45 Colt automatic pistol described in Chapter 32, a small piece of the hard solder ribbon is cut to fit the surfaces being united. With the brush mix a little of the borax with water on the slate to form a paste; both surfaces having previously been scraped bright they are coated with this borax paste and clamped together with the ribbon of hard solder between. Now apply the torch until the parts are red hot and the solder flows; quickly tighten up the clamps as tight as possible. When cool the parts will be found permanently joined, with little if any solder showing at the edges. The borax, however, will be baked as hard as stone, and must be cleaned off by immersion in the acid pickle. This pickle may also be used to clean the parts before joining. When attaching any part to a barrel by hard soldering or brazing, the bore *must be protected* against scale formation with one of the two formulas given in Chapter 21, which are intended primarily to protect file teeth during the hardening process.

Under no circumstances should hard soldering or brazing be employed on any hardened or heat treated parts unless the shop is equipped to re-harden and heat treat them as was done at the factory. The attaching of scope blocks and mounts to Springfield, Mauser, Winchester 54, Remington Model 30, or other high power rifle receivers must be limited to soft solder having a comparatively low melting point.

Brazing proper has little or no use in the realm of gunsmithing, at least on parts of guns themselves. In brazing, the parts to be joined are fitted together as closely as possible—often in special jigs designed for the particular job. The parts are then heated red-hot by means of an acetylene torch, and brazing spelter, usually in the form of fine filings, applied to the joint. Molten spelter has the property of finding its way into the most minute crevices—and the closer the parts are brought into contact, the stronger the resultant joint. On old and decrepit weapons I have seen hammers, sears, extractors and other parts broken and permanently repaired by brazing—yet a much better plan would have been to make new parts from suitable steel.

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Borax is the proper flux to be used for brazing, and it is used in the same manner as for hard soldering. Boric acid is also used in some shops.

Spelter is easiest handled in granular form, like fine filings, and in this form is sometimes mixed with the proper amount of borax, but the proportions can only be determined by experiment—a difficult thing to attempt where each job is different from the other.

An important use for brazing is in fitting new lugs on the bottom of shotgun barrels, or making repairs in places where the resulting streak of brass will be hidden, for of course it will not take the blue when the barrel is refinished. Brazing is also employed for attaching long shanks to drills and reamers for use in barrel work. For this work a spelter having a high melting point is advisable, so that the tools can afterward be heated to the hardening temperature without affecting the joint.

There are many formulas for spelter and hard solder, but as their preparation is outside the scope of even the larger shops, and the quantities needed relatively small, it is always advisable to purchase these materials ready prepared from a large supply house. Tell them the work for which the spelter is required, and depend on them to supply the right grade for the purpose.

Where a torch giving sufficient heat is not available, brazing can often be done in a clean coal or charcoal fire, by using a bellows. A coke fire in a blacksmith's forge is both hot, and clean, and excellent brazing can be done in it. The blower or bellows should be operated until all visible gaseous matter is driven off, and a clean hot fire results. With a poker work a crater in the center large enough to hold the work; the parts, clamped or wired together are then lowered into this crater and the fire blown until the proper red heat is reached. The spelter will of course have been applied before the work went into the fire.

Common spelter usually used for miscellaneous work is a half and half mixture of copper and zinc, having a melting point of about 1660° F., and produces a good strong joint on iron and steel. Coppersmith's spelter is three parts copper and one part zinc. "Gray solder" is a popular spelter made of, copper, 44 parts; zinc, 50 parts; tin, 4 parts; lead, 2 parts. It is free flowing, with a slightly lower melting point than the half-and-half spelter. Another good alloy known as white solder is made by adding 15 parts tin to 85 parts coppersmith's spelter; another good one is made as follows:

A2-1 brass (copper 2 parts, zinc 1 part) spelter ..	82 parts
A1-3 lead-tin solder (lead 1 part, tin 3 parts)	18 parts

Still another is:

Half-and-half hard spelter	85 parts
Lead-tin solder (lead 1 part, tin 3 parts)	8 parts

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The following table illustrates the melting points of various copper-zinc alloys, while the graphic curve will be convenient to the worker of an experimental turn of mind. To find just what mixture will produce a given melting point, lay a ruler parallel with the horizontal line at the desired melting point. The ruler will then cut the curve at a point near the vertical line passing through the proportion of zinc to be used. Thus, for an alloy melting at 1250 degrees, we find we need 80 parts zinc and one part copper.

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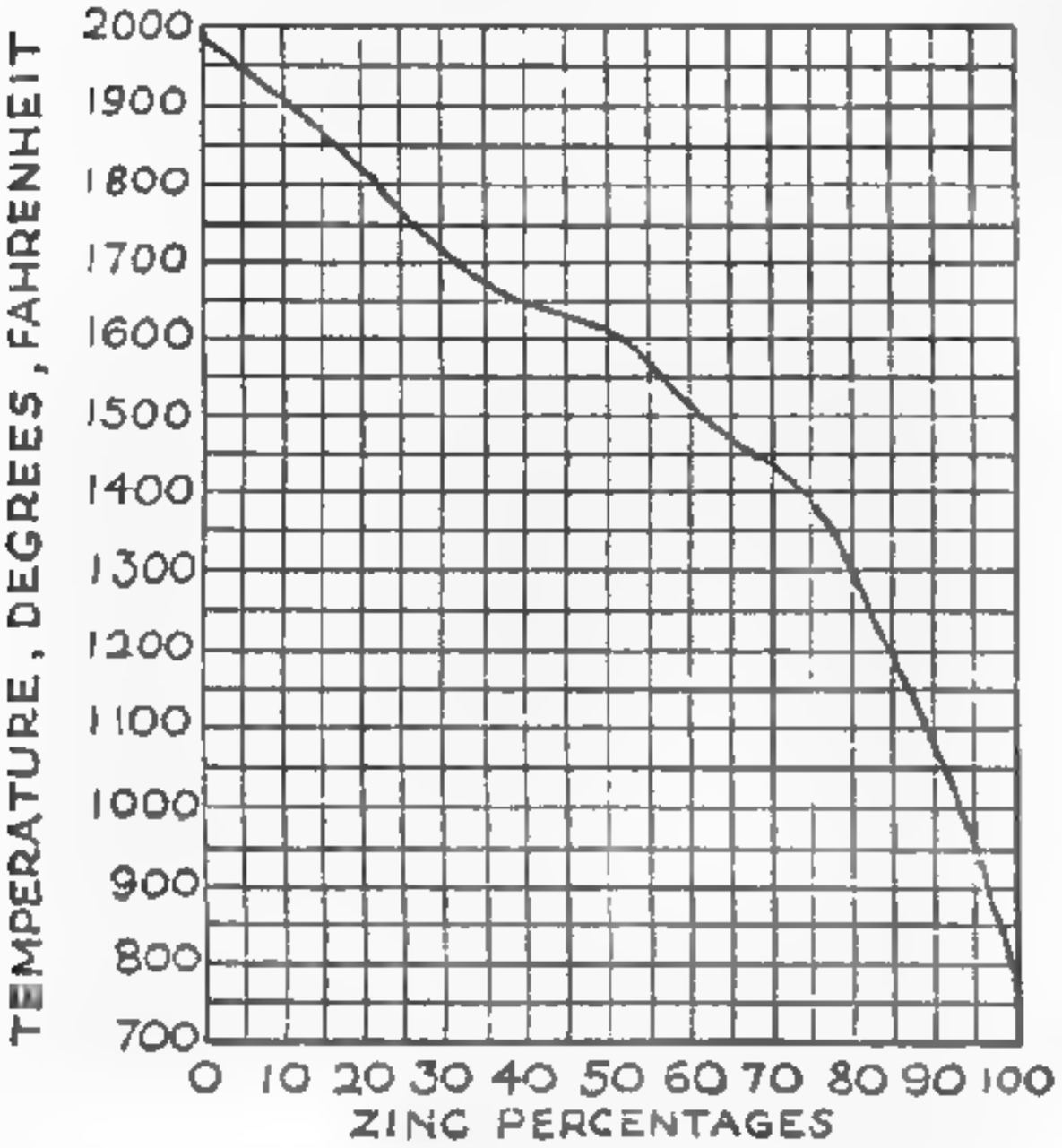
ALLOYS OF COPPER AND ZINC

Percentages in the solder

Copper	100	90	80	70	60	50	40	30	20	10	0
Zinc	0	10	20	30	40	50	60	70	80	90	100
Melting Point Fahr.	1983	1904	1823	1706	1652	1616	1508	1436	1252	1076	786



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For joining German silver and steel, or for articles made of German silver, use the following:

Copper	25 parts
Zinc	65.5 parts
Nickel	9.5 parts

Other very good German silver solders are:

Copper	33 parts	or	Copper	36 parts
Zinc	50 parts		Zinc	56 parts
Nickel	17 parts		Nickel	8 parts

When mixing brazing alloys using lead and tin in composition always melt the brass and other metals with highest melting points first. When the softer metals or alloys are added, stir the mixture thoroughly, cover the surface with powdered charcoal and bring to almost a red heat.

WELDING may be defined as the joining together of two pieces of similar metal by autogenous fusing, in which the two parts are heated to the melting point and molten metal of like character run into the joint.

In the blacksmith's method of anvil welding, which may be stated as a metallurgical process, the surfaces to be joined are brought to melting heat or just short of it, and worked together by hammering.

Electric arc welding is a process by which the surfaces to be joined are heated to melting point at one spot by an electric arc formed between the surfaces and a rod of similar material held close to it. The heat from the arc fuses the end of the rod, and the metal therefrom is deposited in the joint.

Forge welding, as practiced by blacksmiths, is the oldest known form of welding—so common that instructions on the subject would seem superfluous, but for the fact that a machinist or gunsmith is not necessarily familiar with it, and a study of the fundamentals may prove of some value in the repair and manufacture of certain tools.

The success or failure of a forged weld depends on the fluxing. The film of oxide, or "scale" must be immediately washed away and forced from between the surfaces being welded. The metal must be worked only at the proper heat, which in iron and steel is indicated by their vigorous sparking as they are removed from the forge. Sometimes a number of heats is necessary to complete a large weld.

The early gunsmith made his rifle barrels by bending flat bars of iron around a mandrel and welding the edges together, and the perfection of his work is seen on the many fine specimens of flint and percussion arms now so treasured by their owners. In many of them the weld is practically invisible. He used a charcoal fire—the very best for anvil welding, and he "struck while the iron was hot."

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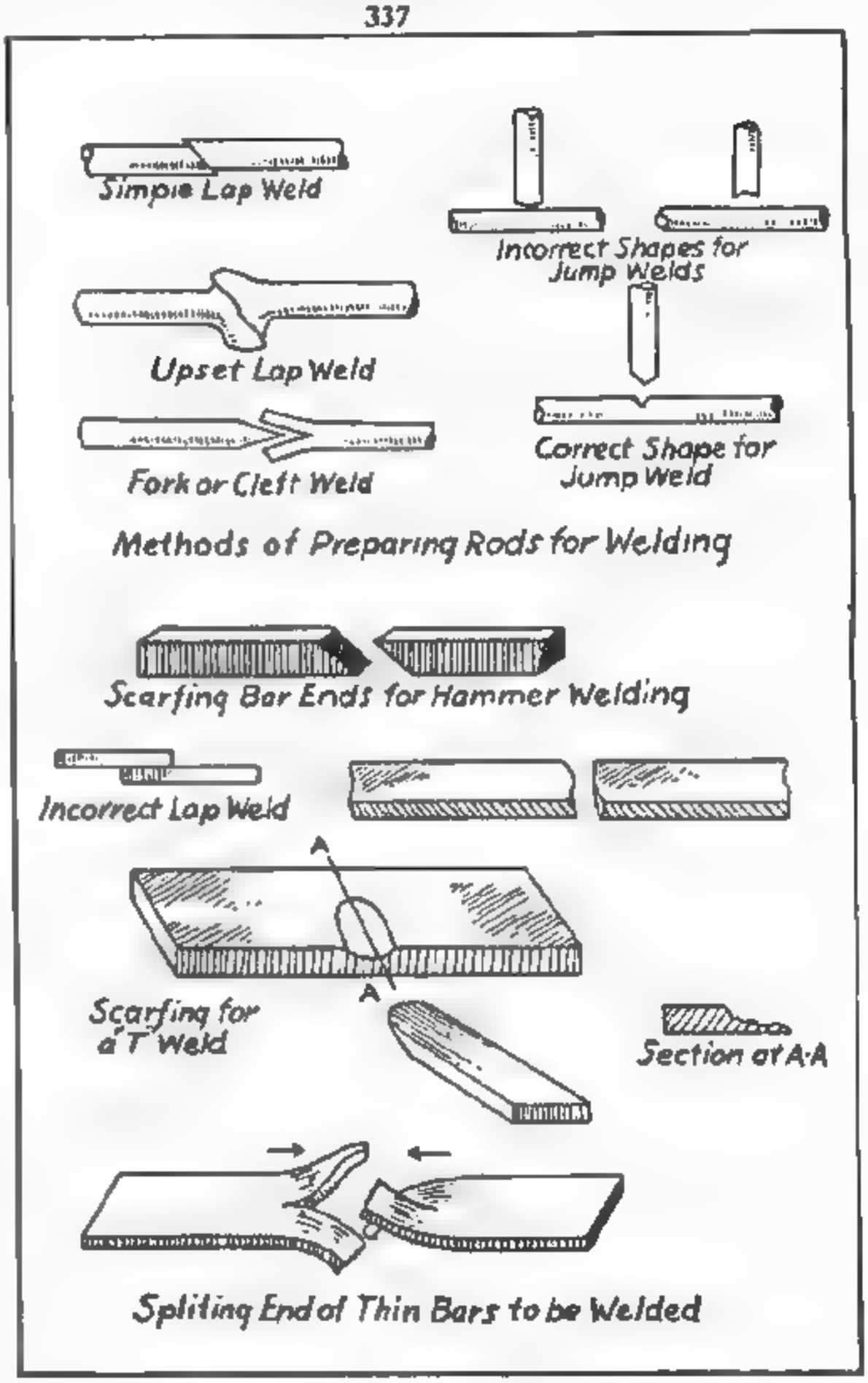

Fig. 132

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The principal disadvantage of forge welding is the large area of metal which must be heated, and the distortion or in some instances the physical changes in the metal, which results from this heating. For example, short reamers and bits used in barrel machines are not adapted to any form of welding because of the danger of burning out the carbon from the steel. For this reason the long shanks of such tools are usually brazed onto the cutters, as the red heat of brazing will not burn them.

Preparation of the work is the first consideration. Figure 132 shows various standard welds, and the method of shaping the ends of parts. For a simple lap weld the pieces are beveled and slightly rounded at the point of union. This rounding permits of the scale that is loosened by the flux being worked out by hammering. In an upset lap weld the parts are hammered out to a larger area than the original stock—this to gain strength because a forge weld has not

more than three quarters the strength of the original metal. The fork or cleft weld is popular for joining two rods together. A jump weld is used for joining the end of one bar to the side of another, and the right and wrong methods of preparing the pieces for this weld are shown. Never attempt a lap weld between the ends of flat bars without scarfing them as shown.

A good forge and anvil, with two or three tongs and hammers, anvil chisel and fuller, constitute the equipment needed. Charcoal makes the best fire; next comes coke. Fine coal may be used, by wetting it down around the edge of the fire so that it forms into coke. The fire should be rather deep in the center and should be blown until all visible gases are burned out.

Place the two ends to be welded in the fire, cover with coals and blow with bellows or fan blower until the two ends are bright red, then drop on them the flux, which may be borax, sand, powdered marble or sal ammoniac—or one of the commercial welding compounds. A mixture of borax and river sand, about half and half, makes a good flux for welding. Return the parts to the fire and bring them to white heat, so that they are emitting sparks; lift them in the tongs, and strike them smartly on top of the anvil, which will knock off most of the scale. Bring the ends together as desired and hammer until nearly cool, bringing them to the shape desired.

There is a knack about forge welding that can only be learned by long experience. Some old-time blacksmiths can weld steel at very low heats—scarcely more than cherry red; while some men never learn to make a good weld. If the reader has ambitions along these lines, he can do no better than to cultivate the village smith and study his form and methods. But blacksmithing is apparently becoming a lost art—the garage now occupies the place of honor under the spreading chestnut tree.

AUTOGENOUS WELDING, usually by means of the oxy-acetylene torch, is the most useful to the gunmaking trade. Yet it

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is a highly specialized trade in itself, and most gun shops find it advantageous and economical to send their welding outside. An oxy-acetylene torch is, however, almost a necessity for many odd jobs of bending, such as bolt handles, etc., where it is desired to keep the heat localized as much as possible, and for this work an investment in a torch and outfit will probably pay dividends even if the shop does not do its own welding. The equipment needed consists of a tank of oxygen and one of acetylene, with suitable gauges for each, several feet of heavy rubber tubing, and the torch. This equipment is shown in Figure 133, and the cost complete will be around two hundred dollars.

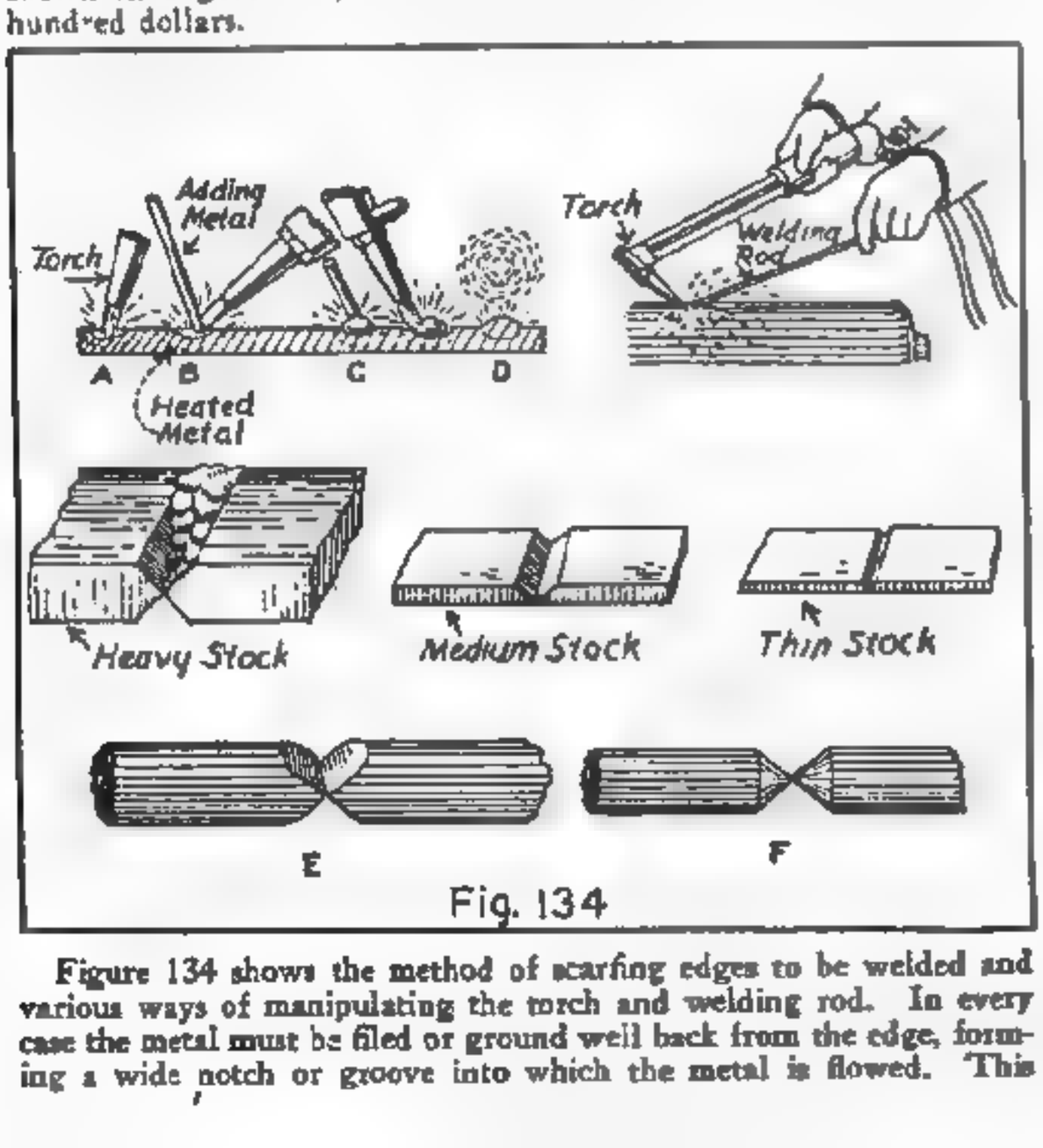

Fig. 134

Figure 134 shows the method of scarfing edges to be welded and various ways of manipulating the torch and welding rod. In every case the metal must be filed or ground well back from the edge, forming a wide notch or groove into which the metal is flowed. This method being entirely different in principle from forge welding, there can be no lapping as is practiced in the latter method. When preparing work for the welder, leave plenty of space for him to fill in new metal. This preparation of the work is important to the shop that sends its welding out. When properly prepared, and clamped or held in suitable jigs, the welder proceeds without loss of time, and cost of the work is kept down to a minimum.

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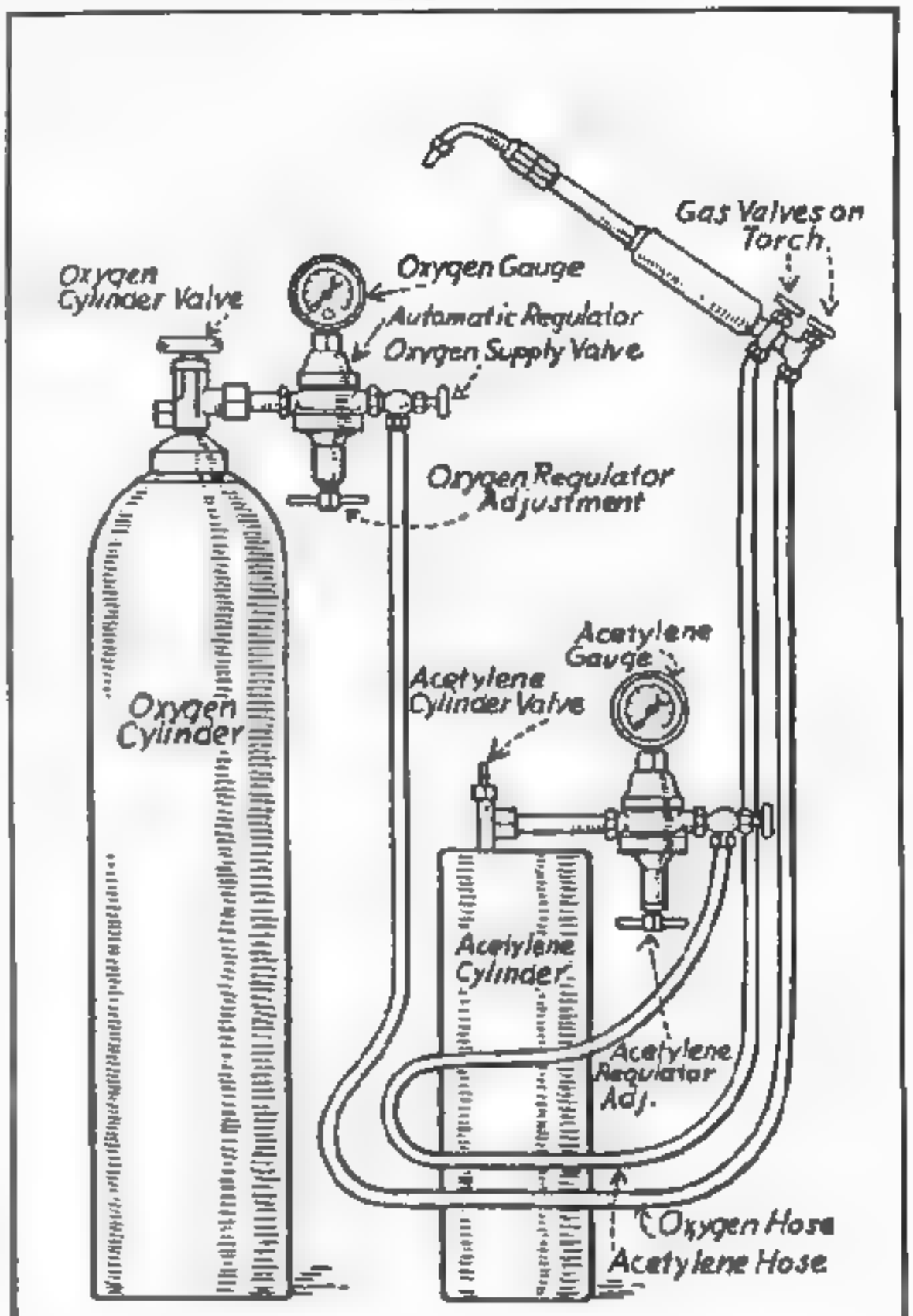

Fig. 133

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ELECTRIC ARC WELDING AND ELECTRIC WELDING differ somewhat in the technique and apparatus employed. The seams of gas tanks on automobiles are often electric welded—but not arc welded. The method employed in the Ford plant is to run the seam, after it is pressed together, through the two copper rollers which form the contacts. These bring the edges of the tank metal into contact, while welding heat is generated at the point of contact, and the two pieces are made into virtually one piece.

"Spot welding" is similar, except that the two pieces of sheet metal are held between the ends of two copper rods carrying current of the right intensity to generate welding heat at point of contact. This is a most useful process commercially, being quite rapid, and the joints permanent. An example of its use may be found in the metal stools and chairs used at soda fountains the legs being thus "tacked" or "spotted" to the metal rim of the seat.

Arc welding may best be understood from Figure 135, which

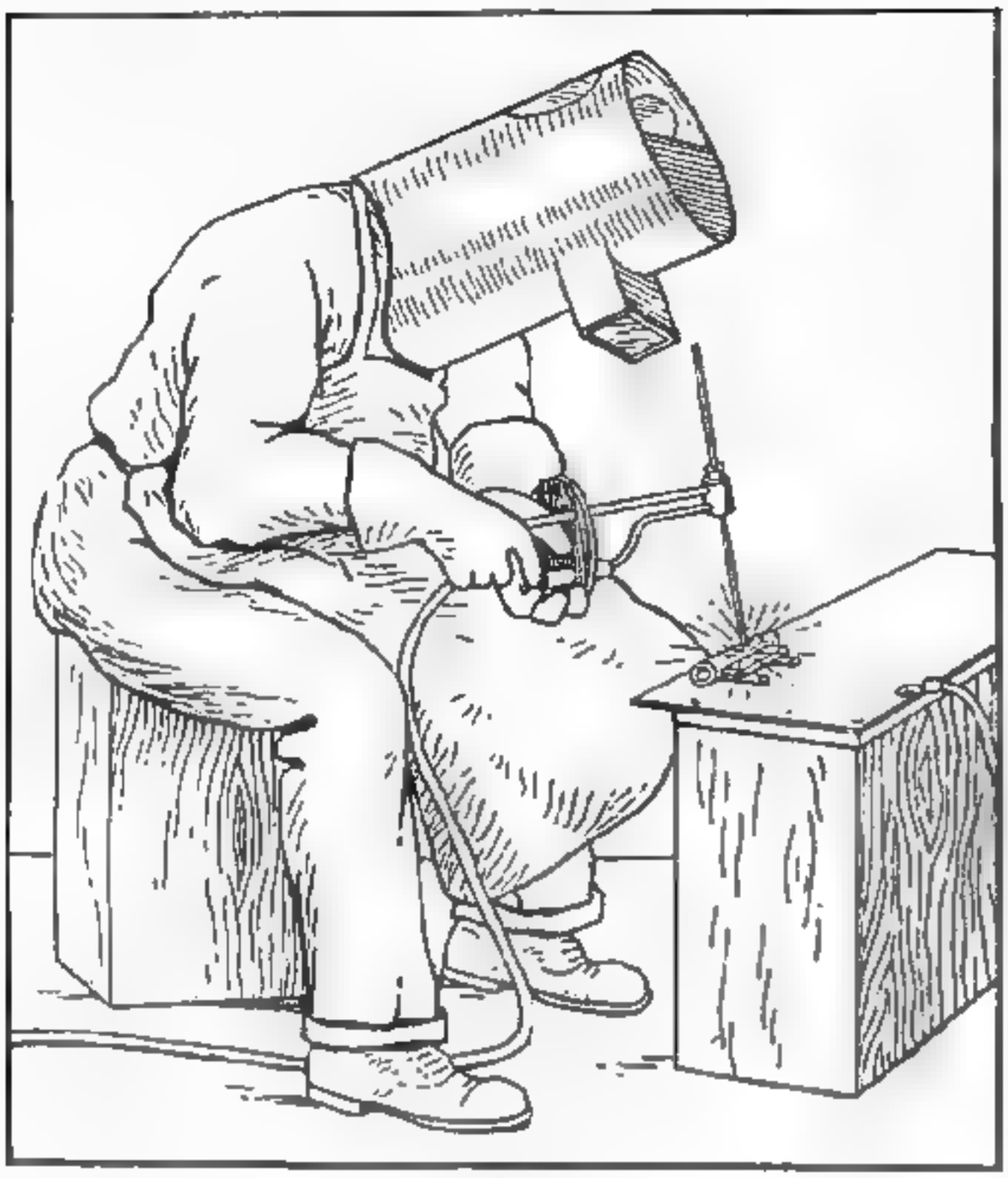

Fig. 135

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shows an arc welder at work and illustrates the operation clearly. As for acetylene welding, the edges must be widely scarfed, and the welder touches the work with the welding rod at short intervals, forming an arc which deposits the molten metal each time it is lifted. The illustration below shows a piece that has been arc welded, before the excess metal has been dressed off.

When sending work out, the welder should always be instructed to not dip the job to cool it after welding. Let it cool gradually, otherwise the joint may harden so that annealing is necessary before it can be finished. When doing any welding or bending on bolt, receiver, or other hardened or heat treated part, the portions subject to wear or pressure (locking lugs, lug recesses, cams, etc.) must be protected by wrapping with wet rags or waste.

The various specific alterations and repairs involving the use of soldering, brazing and welding are discussed in detail in the next chapter.

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CHAPTER 24

MANUFACTURE AND SUBSTITUTION OF SMALL PARTS

MODERN gunsmithing, particularly that branch of the work applying to custom-built arms and remodeled military rifles, as well as special target pistols and rifles, has brought into accepted use many small parts not formerly known on the standard factory products. Many of these are not necessary to the functioning of the arm, nor do they affect its shooting qualities—their principal use is that of convenience in handling, and in improving appearance. The private gunmakers are loath to part with any of these "gadgets" for the use of amateurs desirous of adding them to their own factory and military arms; besides they take the attitude—and a very sensible one it is in many instances—that the man purchasing such parts lacks both the tools and mechanical ability to fit them properly; and they do not care to see their pet "rinctums" cobbled onto guns lower in quality than their own products.

Our logical course, then, if we are determined to have our pet shootin' iron equipped with sun parlor, sunken bath tubs, disappearing beds and all the latest gadgets, is to make and fit them ourselves. And happy to relate, their making is not beyond the reach of even the amateur after he has acquired reasonable familiarity with his tools, provided he follows instructions carefully.

Much of the material needed for barrel bands and the like will not be found in the ordinary hardware store, but must be purchased from machinery supply houses; among these may be mentioned the Cleveland Tool & Supply Company, Cleveland, Ohio; Standard Supply & Equipment Co., Philadelphia, Pa.; the Ellfeldt Hardware & Machinist's Supply Company, Kansas City, Mo.; and the M. L. Foss Machinist's Supply Company, Denver, Colo. There are doubtless a number of others able to serve equally well—I merely mention these firms as I happen to know that they carry large stocks and are thoroughly reliable.

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PLUNGERS AND THEIR USES. The simple plungers shown in Figure 136 have a variety of uses, particularly in remodeling. Their construction is quite simple, and the method of fitting also, particularly if one has a good drill press with suitable vise on the table for holding the work. One or two V-blocks with clamps are also useful.

In Figure 136, A shows a ball end plunger, which is useful for taking up the jump in a bolt handle when the gun is fired; also for forcing the bolt firmly against one side of receiver to assure alignment of a cocking piece sight, and similar uses.

The Krag rifles, for example, usually have a fault common to the Model 30 Remington, some Springfields, and many Winchester 54's and other bolt actions—that is, when the gun is fired, the bolt handle jumps up an eighth inch or so. This fault may be entirely eliminated by setting a small ball-end plunger in the edge of the right receiver wall at rear end, and drilling a small depression in the front edge of bolt handle where it touches the plunger. The spring forces the rounded end of plunger into this depression holding the handle down firmly until it is raised by the shooter. A similar plunger may be set into some bolts near the rear end to bear against the inner wall of receiver, or else into the receiver wall to bear against the side of bolt, forcing it tightly against the opposite wall, and giving assurance that the cocking piece sight will be correctly aligned each time the bolt is closed.

B, Figure 136 shows a plunger that is useful in connection with caterpillar sights when fitted into a ramp, and for other uses. A tenon is turned on upper end of plunger, the plunger setting vertically into upper edge of ramp under the forward end of the sight. When inserting the sight the plunger is forced down out of the way. A hole large enough to receive the plunger tenon is drilled in the flat tail piece at front end of sight. When sight is fully in place in its slot, the plunger snaps up, the tenon going into this hole. The end of tenon should be filed flush with upper surface of the sight tail. To remove sight, simply press in plunger with match, pin, or bullet point, while pushing sight forward out of the slot. Be careful to hold thumb over plunger as sight is removed, so that plunger and spring do not jump out of the hole. This cannot occur if a pin is used to hold the plunger, as shown at B, Figure 136, but the pin may be omitted on a sight plunger if desired.

Plungers should always be made of good steel, and should fit the hole very closely, but not too tight to slide freely. Drill rod of the right size makes good plungers with a minimum of turning or filing. The square notch is cut with a file, to accommodate a transverse pin which prevents the plunger jumping out when the pressure is removed. It is easiest to shape up the bottom end of plunger on a piece of stock several inches long; cut the notch and fit it into the hole on the spring, then mark and cut to length, afterward shap-

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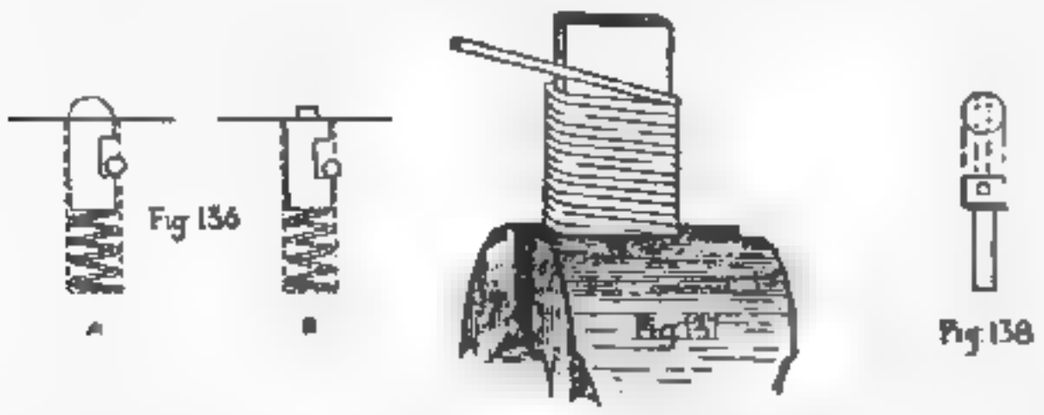
ing the upper or outer end as required. Any plunger subject to much wear must be well hardened or it will soon become useless.

Even if made of drill rod the best method is to case-harden them in cyanide, then polish the wearing end smooth with an Arkansas hone.



In Chapter 5 I have mentioned round Bessemer steel rods as being the best material for MAKING SWIVELS AND LINKS FOR SLING STRAPS. The size rods ordinarily selected for this use is 9/64 inch, and the method of making the swivels and links is as follows: First, rub off the copper coating by drawing the rod back and forth through emery cloth held in the fingers. Next make up the bending form by taking a piece of flat bar cold rolled steel and rounding the edges by grinding or filing. This bar need be no more than six or seven inches long; its width and thickness to be the dimensions desired for swivel or link. A swivel to take the 1 1/4 inch government sling should be 1 1/4 inch by 5/16 inch inside—so make the form from this size bar; a 7/8 inch sling calls for swivels and links bent on a 7/8 by 5/16 inch bar. Set this bar upright in a strong vise, with one end of the Bessemer rod caught by the vise; then wind the rod around the forming bar in a close spiral until all of it is wound up—see Figure 137. Strike each coil on the flat side with a hammer after bending over the rounded edge. When the entire rod is wound like a spring on the forming bar—or when you have as many coils wound as you expect to need cut the coils down the center of one flat side with a hacksaw, when they will drop off the bar. The coils will be perfectly formed links except that the ends are twisted sideways an amount equal to the diameter of the stock. They may be blued at this stage, or the entire swivel assembly may be blued together. If making links for sling, bring the ends together smoothly by holding the closed side in a vise and bending the ends toward center with straight jaw pliers. Then buff them on the wire buffing wheel, and blue by the heat and oil method described in Chapter 20.

SWIVEL SCREW. The loop or link is only half the swivel; but before going into details of a finished swivel with screw and link permanently joined, we must consider the type of screw necessary for use with detachable swivels. As these swivels (Figure 151C) are just a trifle over 1/2 inch between the side bars, we need a

screw with head 1/2 inch in diameter. Any machine shop can make this in a few minutes. The head should be about 3/8 inches in depth, and should have a No. 25 hole drilled through it from side to side. The threaded portion should be 1 inch long, and may be cut short as required after it is finished. 7/32 x 32 is the best size if the screw is to be attached to a barrel band through the forend. If a butt swivel screw is needed, use the coarsest possible thread, so that it will hold in the wood without pulling out.

Figure 138 shows the screw blank before it is threaded, and front and top views of the head. If you have no lathe and buy these

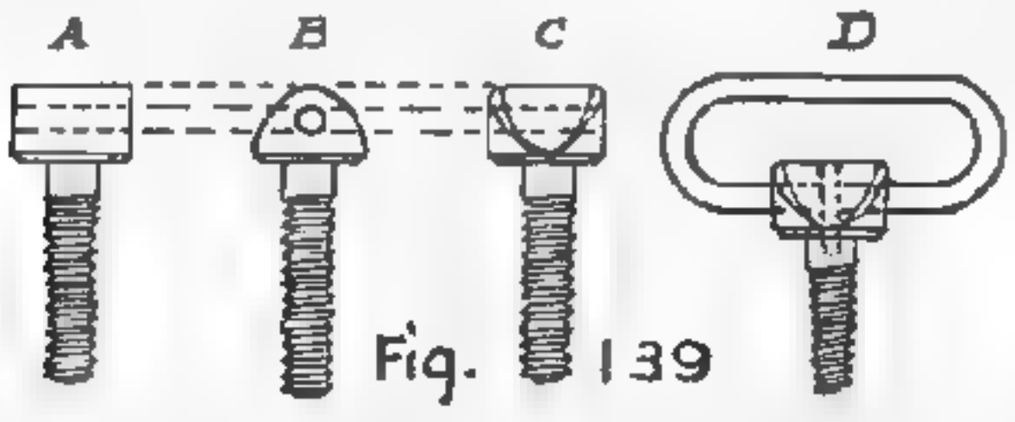


Fig. 139

from a machine shop, have them leave the head cylindrical as A, Figure 139. Then you can file it to the shape shown in Figure 139B, or shape it up on the emery wheel. An easy way to do this is to slip a No. 25 drill through the hole in head. Hold the drill in right hand, with head of screw resting on tool rest of grinder, point of screw held in left hand. By rocking the point up and down while the head is held against the wheel by means of the drill, the grinding can be perfectly controlled, and the head almost finished on the grinder.

A cheap substitute for these lathe made screws is a 5/16 inch hexagon head cap screw (S. A. E. standard). This head is just 1/2 inch diameter between the flat sides. By grinding or filing it round, and drilling the hole through it for the swivel it does very well, although the screw portion is really a bit too large and thread too coarse for best practice. This will cause the swivel to loosen and turn sideways if the strain on the sling is in that direction, but it cannot of course make more than a quarter turn.

A screw of the type described may be fitted through a hole in the forend and into the stud on underside of barrel band. The detachable swivels may be instantly snapped on or off and when the sling is not being used, the heads are small and inconspicuously "streamline" in appearance.

But suppose we want to use the wider strap, for which detachable swivels are not available. A fixed swivel is easily made from the same screw, as follows: Take one of the links already prepared, and spread the ends sufficiently so that one end can be pushed clear

through the hole in screw head; then bend the ends until they meet in a straight line, and slip the swivel back until the two ends are in the center of the head. Now drill a 1/16 inch hole through center of head and drive in a pin made from drill rod; this pin entering between the open ends of swivel holds it in place, and gives the swivel slight tension so that it will not work loose and rattle. The screw head around the pin should be peened lightly to keep the pin in tight, after which the head is ground to shape, filed smooth, polished and blued. The method of pinning in the swivel is clearly shown in Figure 139D.

A good substitute for the swivel screw for use with detachable swivels may be made from an old government swivel from Springfield or Krag. Cut the swivel in two and pull the pieces out of the base. There is a pin through the center of hole in base. Run a No. 25 drill through the hole to cut out this pin—and there you are. The base is just the right width for the detachable swivel, the bar of which fits through the hole nicely—and this type of swivel base is even less conspicuous on the rifle than the screw head previously described.

If a swivel base of this type is to be used for the forend swivel the barrel band should be of the type shown in Figure 147, with filister head machine screws through the holes in swivel, extending through forend and into the block to which band is attached. On a target rifle with heavy, stiff forend, it may be preferred to omit the barrel band entirely, the swivel base being merely attached with wood screws.

Here's an easy way to fit these swivel bases into the stock: hold base in position and mark around it with a sharp scriber; also scribe outlines of screw holes. Center these holes accurately, and bore in with a 1/2 inch augur bit—just enough to cut the outline to the required depth with lips of bit. Use a flat, or slightly hollow chisel to cut out the wood between bit cuts, and even up the bottom with the bottoming tool used in stock inletting. With a very little trimming up of the edges the swivel base will flush perfectly.

In remodeling a military or obsolete rifle one may desire to use the old outside barrel band because it fits the barrel perfectly, yet this band may have no swivel and no place to put one. This can easily be overcome by taking one of the swivel screws already described, and after shaping up the head, cut off the threaded shank leaving just enough to reach through the bottom of band and project slightly on the inside. Drill and tap a hole in band and turn the screw in tightly, taking care that the hole through head stands crosways when the band is on the barrel. The inside of the hole should be slightly countersunk, and the projecting end of screw peened or riveted tight. To do this, stand the screw and band on a block of lead to prevent marring, and use a drift punch to reach to the inside end. This end after being riveted, should be filed

off flush with inside of band. If the band requires bluing, it is a good idea first to heat it red hot and flow in a little brazing spelter from the inside onto the end of screw. The spelter will go into the threads making a solid brazed joint, so that the screw can never loosen.

A still better way is to take the band to a good welder, and have him melt on some mild steel to form a good sized lump on bottom of

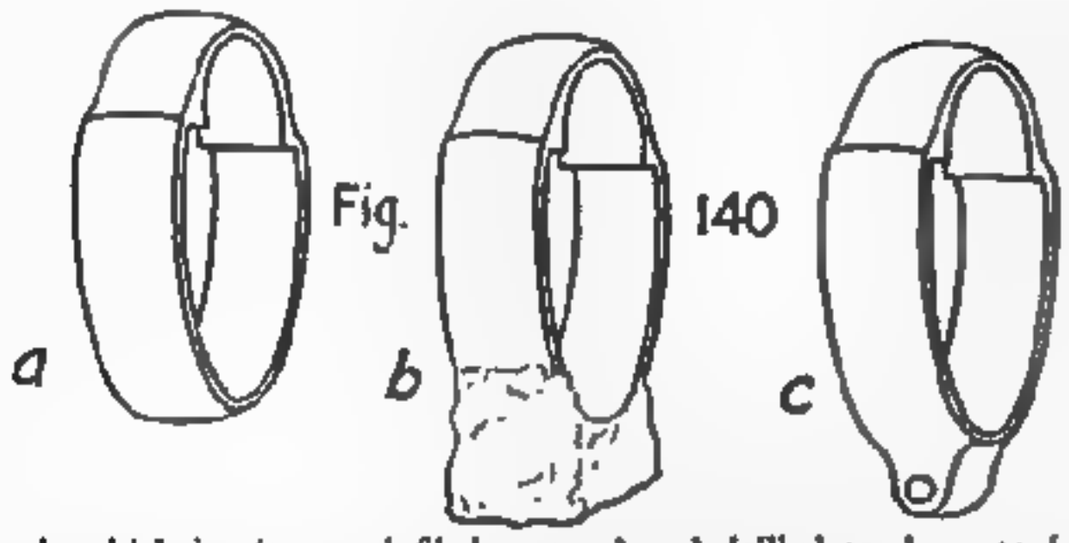


Fig. 140

band, which is afterward filed, ground and drilled to shape to form a swivel stud, as shown in Figure 140. This may be used for detachable swivels, or may be fitted with a fixed swivel, by pinning it in as described for attaching swivel to screw head.

This stunt is of value in remodeling some of the Krags which have a band with cavity for handguard, and are minus swivel. W. Stokes Kirk also sells good outside bands similar to the lower band on the '73 model Springfield, which lacks a swivel. These bands are thick enough to permit their being fitted to different barrels.

MAKING BARREL BANDS. It used to be, that whatever had to be fastened to a rifle barrel was fastened with a screw turned into the barrel, or else by a dovetail slot; and because we didn't know any better, the scheme worked like cats fightin'. But since styles must change, even in shootin' irons, we know now that such antiquated methods are so destructive to accuracy that we can't hit a flock of barns with a barrel so fastened—if we know it. So we use barrel bands instead, as a means of attaching swivel screws, and to hold barrel and forend together, and to provide bases for sights mounted on the barrel—and sometimes to cover up screw holes and other defects in the barrel itself, as well as to provide handguard fastenings.

The very best and most workmanlike bands are made from solid thick-walled Shelby tubing; the band and the stud to which the screw is attached, or which in some instances forms a sight base, being made in one solid piece. Other bands, which answer equally well, in many cases, are made from thin stock soldered, pinned, brazed, or screwed to a thicker block of steel.

Before going into details of barrel band construction, it must be

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remembered that most barrels taper, hence the inside of band must have a slight taper also. Shelby tubing and other soft steels will stand considerable stretching, therefore we select our tubing with inside diameter slightly less than the barrel diameter at the point band is to fit. If possible, select tubing with an inside diameter about the same as the barrel thickness some two or three inches ahead of the final location of band.

First we will make a simple inside band with stud for a swivel screw to go through the forearm; details of this band are shown in Figure 141. Cut a piece of tubing of the proper size about 5/8 inch long; the wall should be from 1/4 to 3/8 inch thick. Hold the piece in a large vise, and with a rather coarse cut hacksaw, lop off excess metal as shown in Figure 142. Now work off the corners on emery grinder, or with a coarse cut bastard file, until the band portion is about 1/16 inch thick. Shape up the base or stud portion so as to keep the sides parallel, and shape up fillets where the base joins the band with a small rattail file. Hold the band in vise so that the jaws press against the edges, not on the sides.

The next step is to locate the point for the screw hole in center of base, center punch it, and drill and tap the hole for the swivel

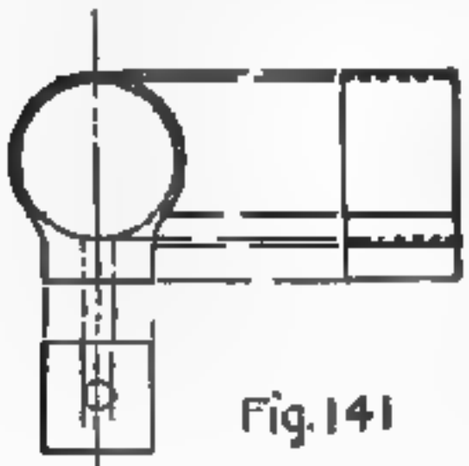

Fig. 141

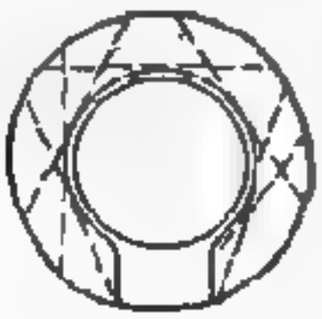

Fig. 142

Fig. 143

screw. Use care to get this straight in line, otherwise the swivel will set at an awkward angle. Now we are ready to fit the band to barrel and form the taper. It may be fitted right on the barrel, or if you have an old damaged barrel of the same size and taper, use it instead. Save all old discarded barrels, as they make good forming bars for bands. Another way is to have a number of short arbors turned up with various tapers likely to be needed, and keep them for this work. This is really unnecessary, however, as the band can be fitted right on the barrel without hurting the barrel if you use reasonable care. The only damage possible is to the finish, and if a band is being fitted to a new barrel that is not to be reblued it is sometimes difficult to prevent scarring it slightly.

If the band is very rough inside—and most Shelby tubing has slight marks and ridges left by the drawing process—smooth it out

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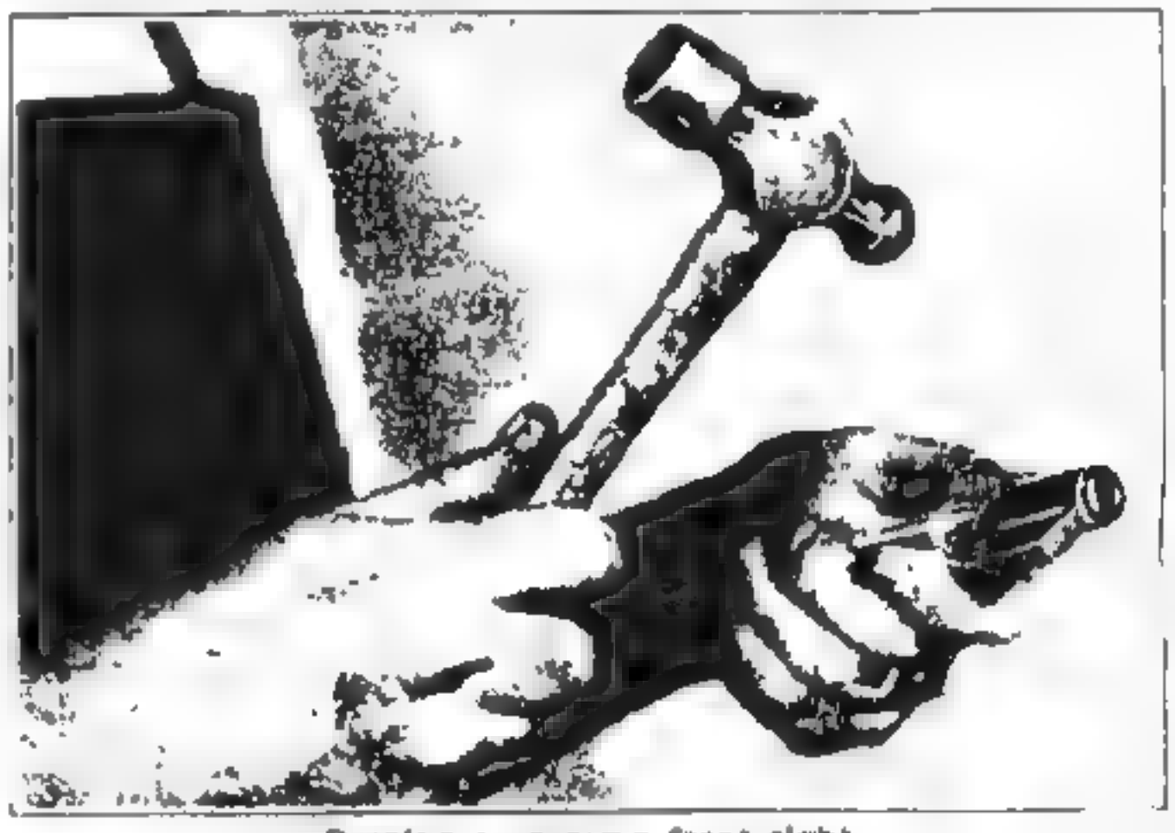
a bit with a straight reamer and polish lightly with fine emery cloth wrapped around a stick or iron rod. Wipe out all grit, and slip the band on the barrel as far as it will go. Now measure and make a light scratch mark on underside of barrel at the exact point where the center of band is to come. With a piece of brass or copper, drive the band toward this mark until it is right on the barrel. Now hold the barrel under the left arm, with hand grasping it near the band, and with a ball peen hammer, peen the band over its entire surface, striking heavier blows along the rear edge where it fits the



Peening on a ramp front sight

barrel tightly. After a few moments of this you will note the band is loose. Drive it further on the barrel until again tight, and continue peening. Gradually the rear portion is enlarged until the band is equally tight at both front and rear edges; now continue peening with equally heavy blows over entire surface, driving the band on further as it is enlarged, until it can just be driven snugly to the mark—or rather, so that this mark on barrel is seen through the screw hole in band. Now peen lightly over the band again to stretch it enough to relieve the strain. You should now be able to slide it off and on by a push with the fingers, the band coming to a definite stop at exactly the right point. It may now be set in the vise and the surface of band carefully smoothed with a fine mill file, and the outer edges slightly rounded. In finishing, bring the band to about 1/32 inch thick with a fine flat Swiss file, such as a 6 inch pillar file; and use it in the direction of the barrel's length—not across the band—in the same manner as in striking barrels.

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Then polish with emery cloth in the same direction, as this makes the band appear much thinner and less conspicuous than when the polishing is done across it. No. 0 emery cloth, if used after it is well worn down, will give a sufficiently bright finish to the band. It is now ready to blue and put in place on the barrel.

A band of this type must be put on before the front sight or its base is fitted; such a band is usually used when the entire barrel has to be reblued, in which case it may be blued with the barrel. Leave it loose on the barrel, so that the bluing covers the barrel's entire surface; if the band is pushed to place before bluing, the portion of barrel under band is not blued, and if it is found necessary later to change the location of band slightly, there will be an unsightly

bright ring showing on barrel at the edge of band.

If the stock is already made, the next step is to inlet the band into forend, which is easily done by pressing it down firmly to get the impression of the corners of stud. Cut out the square cavity with a chisel, then coat under side of band and stud with lamp black and oil, and spot it into place with fine chisel cuts. Very great care is necessary to avoid gaps at edge of forend where it meets the band. Also, be careful to secure absolutely equal pressure against the band on all sides. It is usually advisable to relieve the wood just enough so that it does not quite touch the band on sides, except at extreme upper edges. The cavity into which the stud rests should also be 1/16 larger all round for safety from side pressure. The bottom surface of stud should just touch the wood with the same pressure as the barrel exerts against the bottom of channel.

Coating the bottom of stud thickly with lampblack will locate the position of swivel screw hole, which is drilled from the inside; as soon as the point of drill shows on bottom of forend, finish the hole from the outside. Ream the hole larger than the screw to avoid any strains. An escutcheon or bushing set into the wood is not necessary with the swivel screws previously described, but may be used if desired. They are easily made from brass rod or thick walled tubing, turned to shape as shown in Figure 143. Shallow notches or teeth should be filed in the edge of the shoulder, to prevent it turning after it is fitted into the forend. This escutcheon should be set in flush with the surface of the wood, using a counterbore to cut the space for the shoulder, or cutting it out carefully with a half round chisel of the right size.

In my opinion it is not necessary for a band to be fitted with a noticeable gap showing between it and the barrel. A snug push fit is not going to affect the shooting of the barrel in the least, nor will it cause constriction. The thin band will expand with heat even faster than the barrel does, and bands fitted in the manner described have never given me one bit of trouble—and they surely look better than a band sticking up away from the barrel, as some fit them.

Figure 144 shows a type of special band that has proven particu-

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larly valuable to me. It is cut from tubing in the manner already described, but has a slot or keyway cut to one side of the swivel screw hole of a size and depth to permit of its being slipped over the Springfield fixed stud. This band is most useful on the D.C.M. sporters when the owner desires the forend shaped up a little, and an inside band fitted. The band should have the keyway cut out first, then the outside roughed to shape, and peened to size over an old barrel. It is then finished and blued, the movable stud taken off the barrel, the band slipped to place, and movable stud put back. A screw for use with detachable swivels may be used in connection with this band if desired.

Figure 145 shows a band made in two pieces, the band being attached to the base block with four small screws, two in each end of

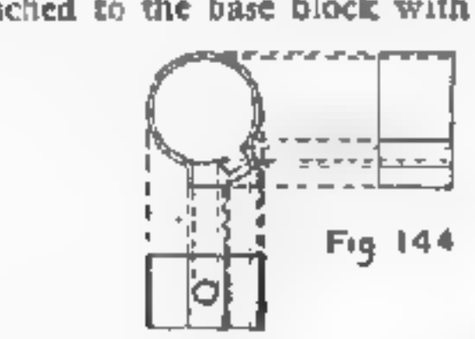
Fig 144

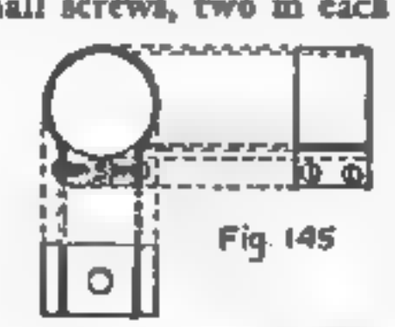
Fig 145

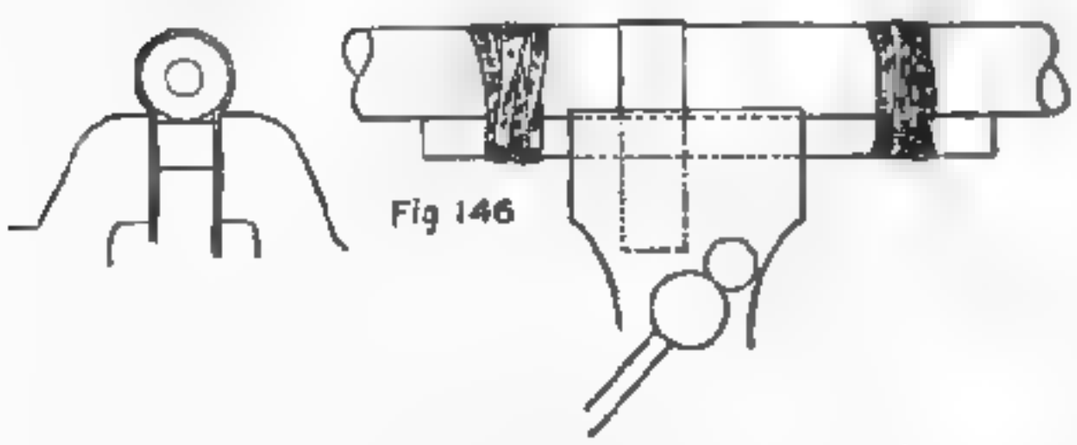
Fig 146

the strap. The method of forming the band is clearly shown in Figure 146. A piece of square steel the same width as the base of band is to be made is taped or wired to the barrel as shown; a U bend is made in the band stock, and the piece then "straddled" over the barrel, and the vise set up tight. The base is made by milling or filing a hollow approximately the same as the curve of the barrel in a piece of cold rolled steel 1/2 x 3/8 inch. Two holes are then drilled in this and tapped for 2 x 56 machine screws, and corresponding holes of "body" size for the screws drilled in the ends of band. The screws are cut off so that they will not quite meet in the center of the block. Use filister head screws, but file the heads to about half their original thickness. Some use rivets instead—which makes things rather tough in case you want to remove the band some time.

This band is made from 1/32 by 5/8 inch cold rolled steel, and it should be fitted to barrel a couple of inches ahead of its final loca-

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tion, then peened to a perfect fit after it is assembled. It should then be filed smooth, polished and blued before putting it on to stay. This type of band looks simpler than those made in one piece—but actually there is about as much work in one as in the other, and the one piece band is much to be preferred.

A variation of this band, for use with standard swivels or swivel bases is shown in Figure 147. The base block is made longer, and is attached to the band with two screws instead of four. Holes are drilled and tapped in each end to take machine screws which hold the swivel in place. If desired the swivel loop may be removed from the base, and detachable swivels used, as already explained. This

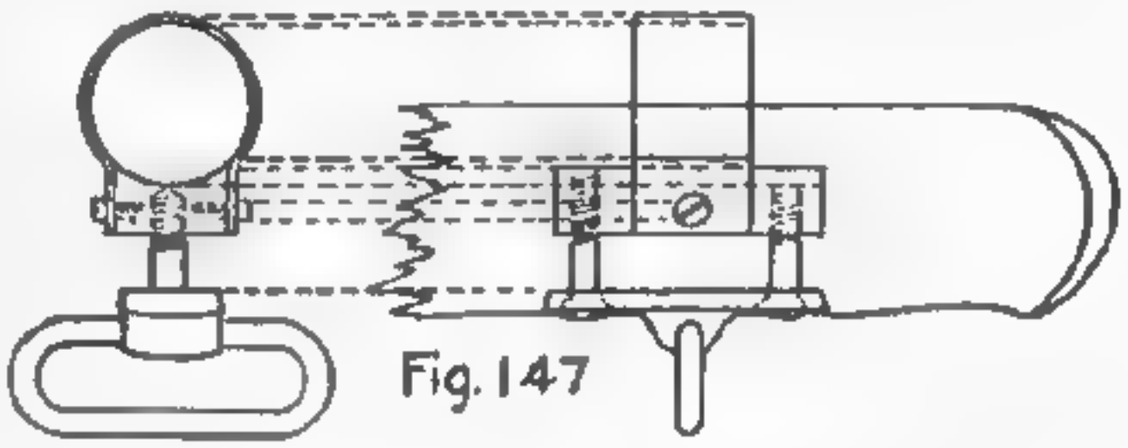
Fig. 147

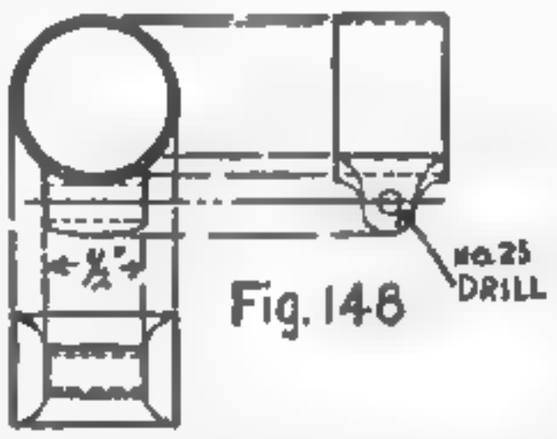

Fig. 148

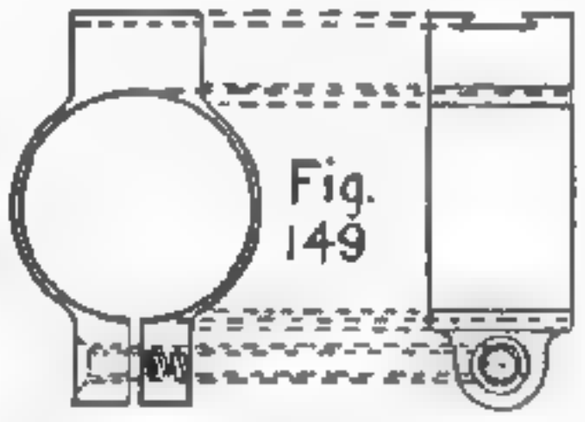
Fig. 149

is really better than the single swivel screw, as the latter may loosen and turn sideways from the pull of the sling, while a base of this kind is always in line.

Figure 148 shows an excellent swivel band for use on rifles where the forend is not fastened to the barrel. This band is stretched and peened to fit the barrel two or three inches ahead of the forend, and sweated into place as described in Chapter 23. The stud portion is made 1/2 inch wide and drilled with a No. 25 twist drill. The shaping of this stud by filing requires careful work, but the appearance warrants the effort required. Make the band of thick walled Shelby tubing, in the same manner as other solid bands are made. It may be soldered to the barrel before the final filing, the band dressed down to 1/32 inch thick or less, and barrel and band polished to-

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gether before bluing. The removal of excess solder and the polishing operations are described in Chapter 18.

The gunsmith having a number of calls for bands of any particular type will find it both convenient and economical to have tubing of the right size roughly milled to the outer shape of the bands required, and keep it on hand, sawing off a 5/8 inch length whenever a band is needed. This work can be done on a milling machine or planer to within 1/64 inch of finish measurements, and will save a tremendous amount of hand work. For bands like that shown in Figure 148, the tubing should first be turned to the contour of the swivel stud, then the excess metal milled off, leaving the row of finished studs with about 1/8 inch of space between them allowed for cutting off and finishing.

There's more than one way of killing a cat. Not long ago a man wanted this type of band mounted on a Single Shot Winchester with a No. 3 round barrel. Although he had used the rifle for

years, the bluing of barrel was in perfect condition, so he demanded a band fitted without soldering and reblaing. Due to the thickness of the barrel, the caliber of which was the .25-20 S.S., this was easy. The band was made and shaped to exact size on an old barrel. A hole was drilled straight in from outside through the exact center of the swivel stud with a No. 22 drill until the drill struck the solid metal above the swivel bar hole; the hole was continued through the band with a No. 31 drill, and this inner portion tapped for one of the 1/8 x 48 screws furnished for attaching the Lyman 48 sight. The band was pushed tightly to position on the barrel and firmly seated with a couple of light taps with a piece of brass. The No. 31 drill was then inserted and the hole continued into the barrel about 5/32 inch, then tapped clear to the bottom.

The screw head was cut off and the end slotted, then the screw turned into the hole tightly, so that it projected into and blocked the swivel bar hole in the stud. A No. 25 drill inserted into this hole cut the projecting end of the screw out of the way, and the job was complete. With the swivel in place it is of course impossible for the screw ever to loosen, and the band is on to stay.

The band was of course blued before being set in place, and while the hole in outer portion of stud shows, it is not particularly objectionable.

Another way to fit such a band without refinishing the barrel is to fit the band and carefully mark its location on barrel; then carefully file off the bluing from barrel where the band covers it, keeping slightly inside the lines; tin this place with a very soft bismuth solder melting at between 200 and 300 degrees; also tin the inside of band with same solder; fit it in place and apply just enough heat to melt the solder, and quickly wipe off any that runs out from under the band—the bluing of the barrel will prevent it sticking, and this much heat will not affect the color in the least. The

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fact is, on a small caliber barrel as heavy as a Winchester No. 3, one would be perfectly safe in merely shrinking the band in place, seating it while hot with a few sharp blows with a heavy piece of brass or copper. It would surely stay put, and such a heavy barrel shooting light loads would not be constricted with the heat of firing.

SIGHT BASE BANDS. Many shooters having rifles equipped with peep sights, wish a folding leaf sight on the barrel also. It serves to check the alignment of the peep sight, and would also come into good use if the latter were broken. Figure 149 shows a sight base band to serve a two-fold purpose on a Springfield sporter, and details of its construction will suffice for all bands of the same general type and purpose. This one, fitted to the breech of barrel at the receiver, conceals the unsightly notch or groove where the wedge shaped pin fitted under the military sight base, in addition to, providing a new base for the Lyman No. 6 folding leaf. It may be either milled, or sawed and filed from thick walled Shelby tubing having an inside diameter of 1 1/8 inch. (See Chapter 5). The stud forming the dovetail base for the sight should be left full height until after the band is fitted; the method of ascertaining the correct height to cut it to bring the leaf sight to proper height, is fully explained in Chapter 29. The two studs or bosses into which the set screw fits are first shaped up as one, then split by a hacksaw cut which does not go clear through the band until after the screw hole is drilled and tapped. After locating the position of this screw hole and center punching, use a No. 18 drill until the sawcut is reached; then drill on through the other half of boss with a 29 drill, and tap this hole for an 8 x 32 screw. Countersink the No. 18 hole for the screw head, which may be filed down a little to flush it. Then saw on through the band. This may be attached without removing the front sight by merely spreading it slightly with a screwdriver and fitting into place, then tightening up the setscrew. The band and lower projections must then be spotted and inletted into the stock.

The lower stud and set screw may be eliminated by making the band solid and drilling a hole for a headless screw in the sight base portion; however, if the band is loose enough to go on without scratching the barrel, the setscrew will force it slightly upward, raising the sight a trifle, and leaving a small gap between band and barrel. Another way would be to turn or ream the band to a tight fit, and shrink it on, after first bluing it. This plan is objectionable because of the necessity of first mounting the band temporarily in order to ascertain the height of sight base. Once shrunk on, its removal would be very difficult, perhaps impossible. The clamp method is undoubtedly the best of the lot.

On rifles which originally had rear sights attached to the barrel ahead of receiver by one or more screws, it is not necessary to make a split band. The set screw studs should be eliminated and the

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band made solid. Peen it to size and taper, and ascertain the height required for the sight base; cut to correct height, file in the dovetail and fit the leaf sight. Now remove the sight, and in the center of the dovetail drill straight down, a hole that is "body" size for a screw that will fit the old screw hole in barrel. It goes without saying that the sight base band was located so that its exact center came over this screw hole.

Fig. 150

Blue the band and slip it in place. Insert the screw through hole in sight base, turn it into the hole in barrel, and with a small file mark the screw level with bottom of dovetail. Remove screw, cut it to length, slot for screwdriver and turn into place. Drive in the sight, and "thar she be." It is permissible to make the base portion of band a trifle narrower than the base of the sight itself, so that the latter can be moved slightly right or left to zero it, without the difference being too prominent.

When fitting a band of this kind, the screw from the military sight may be used if desired. I prefer to save this special screw with the sight when possible, using a machine screw if it will fit the hole in barrel. It happens that the Krag and '73 Springfield military sights were attached with 8 x 32 screws, so this simplifies matters.

When remodeling the Krag, Springfield, or perhaps other military rifles, it is sometimes desirable to use a plain smooth band at the breech; for example, to cover up the notch on Springfield barrel previously mentioned; or to ease the sudden "jump-off" of the sharp shouldered Krag receiver to the barrel. Figure 150 shows three such bands. "A" merely a piece of 1 1/4 inch Shelby tubing with 1/16 inch wall (giving 1 1/8 inch or exact inside diameter), cut to 3/4 inch length and the forward edge filed as shown; "B" is a more ornamental band turned to shape; both are for the Springfield. "C" is a collar for the Krag, and is turned to shape from tubing. Any of these may be made to a rather tight fit, then blued, then heated just enough to expand them slightly and shrunk on. It is not necessary to spoil the bluing by heating the band red-hot and shrinking it on like a wagon tire. Moderate heat will expand it sufficiently, particularly if the barrel has been kept as cold as possible. In fact, even if the band is rather loose it can be shimmed up snugly with paper, and when closely inletted into the stock, it could not be moved from its position.

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Figure 151A shows a pair of turned collars for use in keeping a handguard in place. One of the simplest ways to remodel a Springfield, if one does not care to reblue it, is to either make a new stock, or cut down and re-shape the military stock; then make a handguard to cover the rough rear portion of the barrel, and tenon the ends to fit tightly under these collars. It is not necessary that they fit the barrel tightly—in fact it is best to have them a trifle loose. The tenon of the band guard wedges under the collar, holding it firmly in place. The forward collar may be drilled and tapped on the lower side for a swivel screw, and the lower half of both collars may be dressed down until only a thin band remains—the overhanging portion being only necessary above the forend, to hold the hand guard in place.

Figure 151B shows another type of handguard band, made from a regular lower band of a Springfield service rifle. A piece of sheet steel 1/32 inch thick was fitted carefully into the upper half of band, and brazed from the inside. This piece was then filed to fit over the barrel, just clearing it without touching. This makes a much neater job than using the old band and letting the end of wood show under it.

FRONT SIGHT RAMPS. Whether or not a ramp does any real good is an open question; but in the eyes of most shooters it

Fig. 151 A

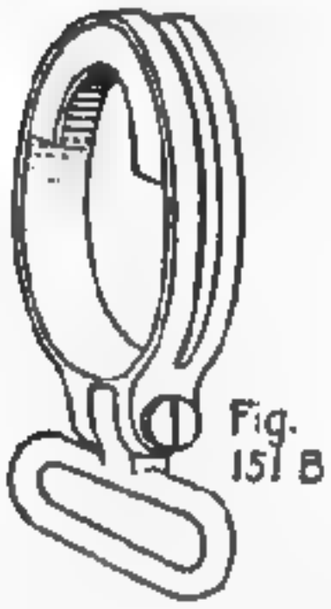

Fig. 151 B

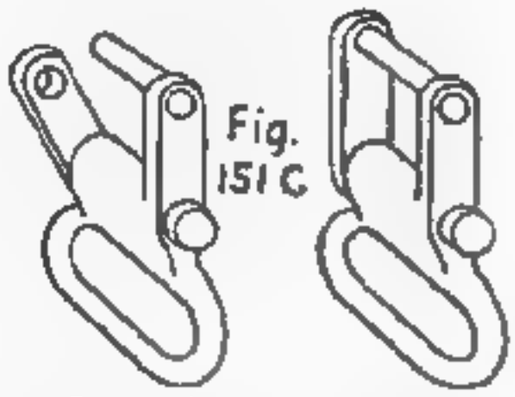

Fig. 151 C

Detachable Swivel

adds a touch of distinction to the arm, and moreover, it helps to prevent barrel mirage from disturbing the aim, while permitting a

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great variety of front sights to be used. With the ramp one is not limited to the use of blade sights made for military bases, but may use any of the dovetail base sights having a rather short dovetail; or he may use the caterpillar sights made by Lyman and Marble if he prefers that type. (See Chapter 29).

Figure 152A shows a type of ramp that is becoming pretty well standardized, the solid lines showing the finished shape, while the broken lines show the original blank. The blank should be made by a machinist who knows his business—it is no job for the appren-

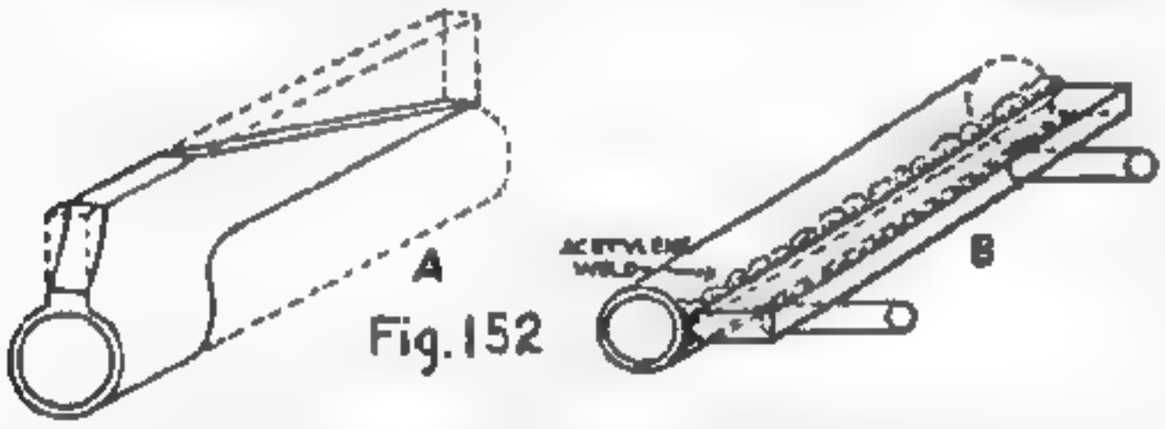

Fig. 152

tice—and it may be made on either the milling machine or shaper. It can be cut from thick walled tubing if the right size is available, or from solid flat stock, using cold rolled or machinery steel. The hole should be drilled and reamed to the exact size of barrel at a point 3/8 inch from muzzle, and it should be a straight hole—not tapered. The trifling taper of barrel at muzzle will assure a snug fit with good contact at rear end of ramp where it is not held by the band. The excess metal of both band and blade should be sawed and filed away, and the ramp brought roughly to shape before fitting. Then start it on the barrel, holding the blade down firmly, and peen lightly until stretched just enough to permit of its being slipped on. Chapter 23 gives detailed instructions for sweating on the ramp, and for pinning if desired. After it is mounted, solder on a temporary front sight, and sight in the arm as outlined in Chapter 29; then follow instructions for ascertaining height for dovetail; cut the dovetail and fit in the permanent sight. This may be mounted before or after bluing—it makes no difference.

A milled blank for front sight ramp will cost from three to five dollars in a machine shop. A cheaper one which is nearly as satisfactory if properly made, is illustrated in Figure 152B and described in detail under the welding instructions in Chapter 23.

The photo in Figure 153 shows a very attractive ramp made and fitted to a 39 Marlin. The original front sight was removed from the barrel slot, and filed down level with the surface of the barrel. A hole was drilled in this base, and a screw through it held the ramp, which was simply a piece of cold rolled steel 1/4 inch thick sawed and filed to shape. Between ramp and sight base a piece of ribbon

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silver solder was placed, with necessary flux, and heated redhot, then the screw was set up tightly in lieu of a clamp. The ramp was then cleaned up and polished, after its correct height had been ascertained, and the top dovetailed for the Sheard bold bead sight made for the Mannlicher-Schoennauer. The whole assembly was then blued, and the dovetail base of ramp driven into the barrel slot. This stunt is only possible on octagon barrels, as the round barrel would show gaps at edge of ramp.

On rifles requiring a very low ramp, the band may sometimes be eliminated. Many Mauser sporters imported into this country have low ramps merely soft soldered to the barrel. Personally I wouldn't carry one of them into the woods, for fear a blow would knock the ramp into the middle of next week—but the Heinies get away with

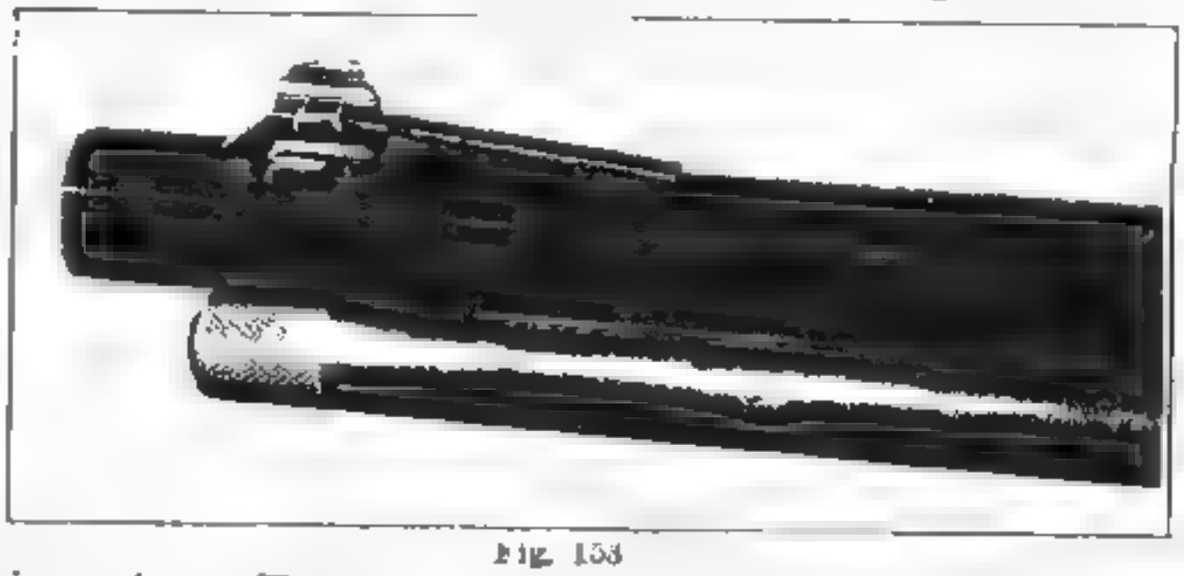

Fig. 153

it somehow. To make and fit a ramp of this kind properly, the ramp should have its lower edge milled hollow, to the exact radius of the barrel at forward end of ramp—in other words, about 3/8 inches from muzzle. A long bar of 3/4 x 5/16 cold rolled can be run under a 5/16 radius cutter on milling machine at small cost —and ramps for the Springfield or other barrel that is approximately 5/8 inch at muzzle can be sawed off as needed. Such a ramp should be silver soldered to the barrel after being clamped firmly at both ends, and unless you want to ruin the bore absolutely, coat it with the file hardening compound described in Chapter 21; this coating must dry slowly for several hours before the brazing is done. Theoretically, there is some danger of warping the muzzle slightly in the brazing process, and the real crank will choose a banded ramp attached with soft solder.

I note that at least one firm is offering a ready-made ramp at about ten dollars designed to be attached to the Springfield barrel. In justice to all concerned I would suggest that the prospective purchaser study the catalog illustration carefully before parting with his ten iron men. The ramp in question is supposed to fit perfectly

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over the spot where the original fixed stud was attached. From experience I know that this size varies quite a bit with different barrels and studs. Moreover, a ramp fitted over the lettering and ordnance insignia stamped on the barrel near the muzzle is going to look like the very devil. Before a ramp is fitted this lettering should be "struck" off and the barrel polished—and if this is done, the "store" ramp will then prove to be too large. The only way a ramp can be fitted—I mean *really fitted*, so that there is no streak of solder showing along the edges, is to make it slightly smaller than the barrel, and fit it *tightly*. Another thing—the ready made ramp is just about half as high as can be used on a Springfield; thus it requires a very high front sight which sticks way up above a ramp, making it fall far short of its purpose. One of the best things about the right kind of a ramp is that it can be made so high that you use a very low front sight, which is thus better protected, stronger, and easier to shoot accurately than a thin, flimsy affair hovering in mid air half an inch or so above the top of ramp.

The entire upper surface of the ramp should be matted, and this process is described fully in Chapter 19.

With a complete machine shop at his disposal, the gunsmith is in position to make a splendid FRONT SIGHT COVER to be attached to the ramp. Such a cover is illustrated in Figure 154, made from 5/8 inch Shelby tubing with 1/16 inch wall. To form, take a piece of 1/2 inch steel drill rod, and mill a flat 3/8 inch wide on one side. Force this into the tubing, and hammer one side of tube flat against the flat portion of rod. The flat portion is then slotted as shown, either with hacksaw and file, or by milling. The closed end may be knurled or finished smooth as preferred. One side of

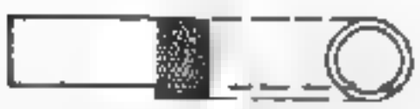

Fig 54

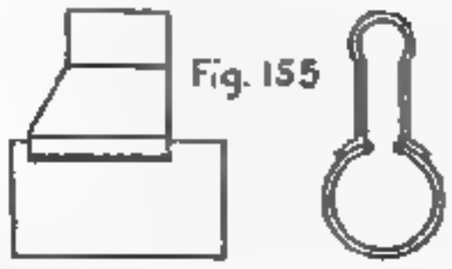

Fig. 155

thus cut near the closed end should be notched as shown, and the point relieved slightly.

The barrel with ramp attached (after the rifle has been sighted in and slot cut for front sight) is now mounted on the bed of milling machine and slots 1/16 inch wide and 1/16 inch deep cut in the sides. The distance of these slots should be figured from the front sight bead, so as to about center the bead in the sight cover. A hole is now drilled in the slot on left hand side of ramp, and a round end pin of drill rod driven into it, the rounded end projecting into slot not more than 1/32 inch. When the sight cover is pushed into place, the edges slide in the grooves in ramp, while the left hand edge rides up over the projecting end of pin, which snaps into the notch in edge

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of sight cover, holding it in place by its natural tension, yet permitting easy removal when desired.

Detailed instructions for setting up and doing this job are not given, for the set-up would vary somewhat with the type of equipment available; moreover, a first class machinist will readily understand what to do from the drawings—and only a first class machinist could do the job.

Figure 155 shows a "tompion" or muzzle cover, with sight cover in combination. It may be made of thin Shelby tubing or hard brass tubing as preferred, to fit almost any rifle. The piece of tubing which slides over the muzzle is partly cut away for the sight base or ramp; and a small projection left on either side snaps over the front edge of sight base, to keep the tompion in place. The muzzle end is closed either by brazing in a round piece of sheet stock, or by threading in the end of a piece of rod equal to the inside diameter; screw this in about 3/32 inch, saw off the rod, file it flush. The sight cover portion is made of sheet brass or steel bent over a round rod in the vise just as you bent the stock for the two-piece barrel band. The lower edges are bent out for about 1/8 inch, and brazed to the tompion. The muzzle end of the tube portion of sight cover may be closed, or left open as desired. Better to leave it open. A gadget of this kind had better be made of brass, and polished—one is more likely to see it in time to avoid shooting it off if an unexpected shot presents itself. I have never shot a tompion off a rifle, and don't know whether the barrel would be damaged or not—don't think it would. But you sure would have the devil's own time trying to find that tompion!

MUZZLE PROTECTOR. Rifles that must be cleaned from the muzzle need a protector to prevent the rod wearing the edge of muzzle. This *should* be made in a lathe. Chuck a piece of steel bar at least 1/8 inch larger than the muzzle diameter, and drill a hole through it endwise barely enough to allow the cleaning rod to slide through. Now counterbore to a depth of about an inch and lap out smoothly to a sliding fit over muzzle. Then mill or saw away enough of one side to clear the front sight. Case-harden, and polish out the inside, to prevent marring barrel. No drawing is shown, as the protector would vary considerably for different rifles and sights. In this day of rustless, smokeless, dirtless and pitless ammunition and bolt action rifles, only the cranks who insist on using the old time weapons are likely to be interested in a muzzle protector. But when needed in a hurry, a good one can be made very easily if you can get hold of a piece of Shelby tubing that will just fit snugly over barrel. Cut it about an inch long, file away enough of the side to clear the front sight. Solder or braze a piece of 1/16 cold-rolled steel over the muzzle end. Center and drill this for the rod—and "thar she be!" Brass tubing is all right, but the hole will soon be enlarged, permitting it to wear the muzzle.

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PISTOL GRIP CAPS. Good ones are hard to find. The cheap hard rubber ones of factory manufacture, as seen on many shotguns are about useless, being small, flimsy and ugly. The best ones are made of cold rolled steel, but the supply is limited to the few made up by the larger custom gun makers for their own use. These plates are expensive, as they are cut out from solid stock on a profiler—which is a milling machine with a vertical cutter that can be moved in all directions. An oval shaped piece of steel is mounted on the bed of the machine as a pattern; a special formed cutter is used, having its end shaped to the edge design wanted on the finished cap, and this cutter is brought against another oval piece from which the cap is to be made. A "finger" bearing against the pattern piece guides the cutter around the stock, shaping the plate as desired. Thus it is necessary to make a special cutter, costing fifty dollars or so, for every edge design wanted, and a special hardened pattern plate for each size and shape to be manufactured. And likely as not, the grip cap of this type purchased (if one is able to purchase it at all) will not conform to the purchaser's ideas of size and shape.

A good plain grip cap may be made from a piece of bakelite or celeron radio panel 1/4 inch thick. Simply mark out the oval to size and proportions desired, cut the bakelite roughly to shape with a scroll saw or coping saw, file carefully to the outline, then drill and countersink the screw hole. In this condition mount it on the grip of the stock, and work the wood down to it, filing both grip and cap until the edges are perfectly even. Then with a medium coarse file, start in near the screw and round off the cap, thinning it toward the edges to about 3/32. Polish with fine sandpaper, then pumice, until smooth and bright.

Grip caps of horn and steel, made for Mauser sporting rifles, can be purchased from firms importing these arms, at a cost of about 50 cents each. They should never be carried in the pocket on Sunday, as their small size involves an ever-present danger of their being accidentally dropped into the collection plate instead of the customary two-bits. They are also fine for operating slot machines. But—they have possibilities. Take the horn cap, and rub the under side smooth and flat on a sheet of coarse sandpaper held on the bench; take a piece of thin horn, bakelite, or even black fibre, say 1/16 or 3/32 inch thick, and larger than the cap. Roughen its surface with sandpaper, and cement the cap to it with du Pont cement, clamping it in the vise for 48 hours. Now dress down the edges all around to the size wanted, the projecting edge of the bakelite or fibre forming an extra bead and increasing the size and shape desired. Drill the screw hole through this piece, and fit it in place.

The Mauser steel caps (which are merely thin sheet metal stampings) can be similarly remodeled, by first filing them to the form of oval desired (they usually have a very clumsy shape, being too round on the ends) and sweating or brazing them to a piece of 1/16

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inch cold rolled steel. Grind or file the edges as desired, round outer edge, scrape and polish off any solder or spelter that shows, and blue. Use the nitre or the heat and oil process if you brazed the pieces. If you soldered them, use a rusting solution, either hot or cold.

The amateur who has pretty definite ideas of his own may not be content with a remodeled grip cap; the thing for him to do it to secure a piece of soft pine, about 5/16 inch thick; cut it to the desired oval, drill a screw hole through the center, and mount in so that it can be revolved on the end of a piece of wood, which is held at any convenient angle in the vise. With file and chisel the edge is shaped up to the desired bead design, sandpapered smooth, and shellaced. Send this pattern to the nearest brass or white metals foundry, and have it cast in aluminum—the cost will not be much. This aluminum pattern can then be filed and polished very smooth and accurate in shape. Finally buff it to a bright finish. This can now be used for the cap, being finished in black as described in Chapter 20; or it can be sent to a foundry and cast in brass, bronze or copper, and given a beautiful black, blue, red, verde antique or other finish. Or it can be cast in malleable iron, carefully file finished, polished and blued. The man with some artistic ability will enjoy working up a grip cap in modeling clay or plaster, with a game head or other figure in relief, and this can then be cast in bronze, the surface engraved, and given any finish desired.

Some shooters will desire A GRIP CAP WITH A TRAP for a spare front sight. If the hole in end of grip is not so large and deep as to weaken the stock, there is no objection to this. The simplest and easiest way to make this is to first make a cap of bakelite as first described. Fit this to perfect contact and cement it with du Pont cement, using the screw to hold it until dry. Remove the screw and drill through the cap and the required distance into the grip, starting with an augur bit and finishing the bottom of hole with a Forstner bit. The size of the hole will depend on the size screw you will

use to close it—somewhere around 1/2 inch. Secure a threaded bolt or large machine screw with a fairly fine thread, slightly larger than the hole. Cut off a piece of the threaded end of bolt about 5/16 to 3/8 inch long. Tap the hole in grip cap for this screw, letting the threads go into the wood of grip for only a short distance. Take the short piece of bolt, and round off the cut end slightly, polish it, and cut a screwdriver slot wide enough to take a small coin. Blue this, and the job is complete. The screw should turn into the hole tightly when its outer end is nearly flush with surface of grip cap, and the slot should be in line with center line of stock. This makes a neat job, and a thoroughly practical one, at practically no cost. A better way would be to make a special screw to close the hole, with a wide thin head having a narrow shoulder.

This same idea can be carried out with the remodeled Mauser grip

[redacted]

cap already described. The cap, being of thin sheet steel, should have the space between its inner surface and the added piece filled up solid with brazing spelter. Then drill the screw hole to required size, and make and fit the screw. Since it is impractical to cement a metal cap to wood, a piece of brass tubing about an inch long and 1/2 inch inside diameter is then brazed to under side of cap; the upper end of tube is closed with a piece of brass brazed on, and in the center is drilled a hole for a short wood screw, which holds the cap in place. A well of this type can also be fitted to a solid cap of iron, steel, bronze or other metal.

Figure 156 shows clearly the method of working out the two methods just described. Very good steel grip caps with a trap door held open or closed by a jack-knife spring, similar to buttplate traps,

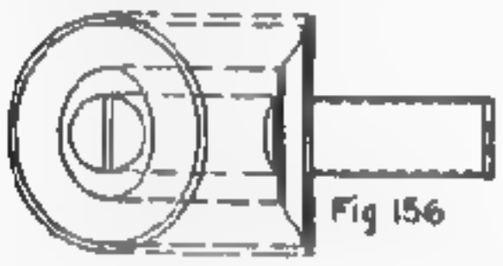

Fig 156

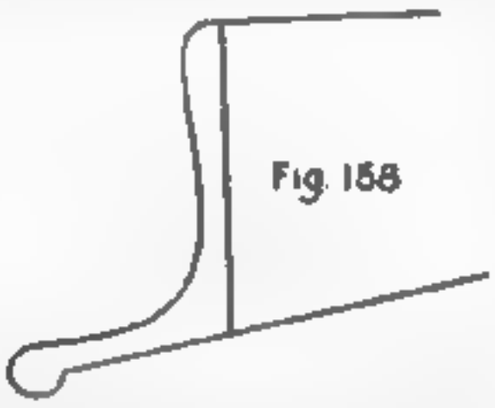

Fig. 158

can be purchased from one or two English firms handling gunsmithing supplies. The screw trap as described, however, answers every purpose, is neat in appearance, and comparatively easy to make.

BUTTPLATES. About the most difficult problem the amateur designer has to face is that of securing a suitable buttplate. Formerly very little thought was given to the hinders of a gun's anatomy, almost any old piece of iron that would prevent the wood from splintering being considered satisfactory. The deeply curved crescent shaped plate was very satisfactory on the old lever actions having only moderate recoil, the shape of the plate keeping the butt to the shoulder while the lever was worked. But with the coming of bolt actions the horns of such a plate were not needed to keep the butt from slipping down, and the increased recoil of modern loads necessitated a type of plate that would distribute the blow over the largest possible area of shoulder, and with no sharp projections to stab and gouge.

The shotgun type of buttplate was found to be the best of all for use on the new day rifle. Its larger size—usually 5 inches or longer, and at least 1 5/8 inches in width, and its nearly straight shape and rounded edges made it the most comfortable as well as the most efficient. Unfortunately, these plates are usually made of the poorest kind of hard rubber, or else of horn, which is somewhat more durable, and good steel plates, which are the only kind suitable

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for the rough use that a rifle usually is given, are hard to find. Winchester makes a very good steel shotgun buttplate for about 60 cents. It is about 1/8 to 1/4 inch narrower than called for by the best rifle design, and an extra 1/4 inch in length would not hurt it any. Belding & Mull make a special buttplate which was designed for the B. & M. Model 30 Remington sporter, which more nearly approaches ideal lines. Neither of these plates has a trap for cleaning materials or what not, and recent custom has brought us to the point of demanding such a trap on the better grade rifles.

Sometimes one can remodel a military buttplate very satisfactorily. The Springfield plate is really too short; a Krag plate, which can be bought from Bannerman for a quarter, works up much better. It has a small round trap, not as desirable as the long oval traps on the expensive imported plates, but far better than none. A man should have acquired reasonable skill at forge and anvil to do a first class job of reshaping this plate. First remove the trap, trap spring and screw. Then heat the toe and straighten out the forward bend. Heat entire plate and curve it very slightly from heel to toe. Heat it again and round the plate slightly from side to side over the horn of the anvil, taking care to preserve the heel to toe curve while doing this. Next heat the trap, and bend it slightly from side to side, and refit it into its hole. This requires very careful work, and it will very likely be necessary to do some filing, due to the hole having been misshapen by the bending of the plate. Work it down carefully until the trap fits close all around the edge, and is snugly seated against the beveled edge of the hole. Now assemble the trap and plate, and file down their surfaces smoothly; round edges of plate and grind or file outer edges to exact shape desired. The long round-end lip at heel can be cut off, leaving only about 1/4 or 3/8 inch projecting, and this ground to a point. The square edge at heel should also be well rounded, and a screw hole drilled and countersunk near the heel, the original hole in lip having been removed. The plate and trap should then be polished, and the surface either file-checked or sharply stippled, as described in Chapter 19.

It's easy to say "file-checked"—doing the job is another matter. I have never found any dependable method for spacing file cuts accurately enough to call it checking; if one has plenty of time and patience, a good sharp 3 square file can be used to turn out a fine job, simply gauging the spacing of the lines by eye; but it is a slow process, and really amounts to engraving with a file. Knurling is usually out of the question without a very costly set-up of special fixtures, so the stippling method, using either a dental engine or a prick punch and hammer, offers the readiest solution.

It is possible to take the B. & M., the Winchester, or any similar steel plate and make and fit a trap in it as desired. The round trap is of course easiest to fit, and may be taken from a Krag or Spring-

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field plate. The buttplate you purpose using is carefully set up in a four jaw lathe chuck, so as to center exactly the point at the center of the hole to be cut. The hole is then turned in, and its edges beveled at an angle of about 45 degrees. The slot for the hinge of trap is filed in, and the trap heated and bent slightly to conform to the curved surface of plate. Careful filing then fits the trap into its seat smoothly. The hinge pin rests at each end in small depressions cut in the under surface of the plate on each side of the hinge slot. The easiest way to cut these depressions is with a dental engine and round burr. Lacking this, make a shallow indentation with a drill just back of the edge, and chip out the metal at edge with a small

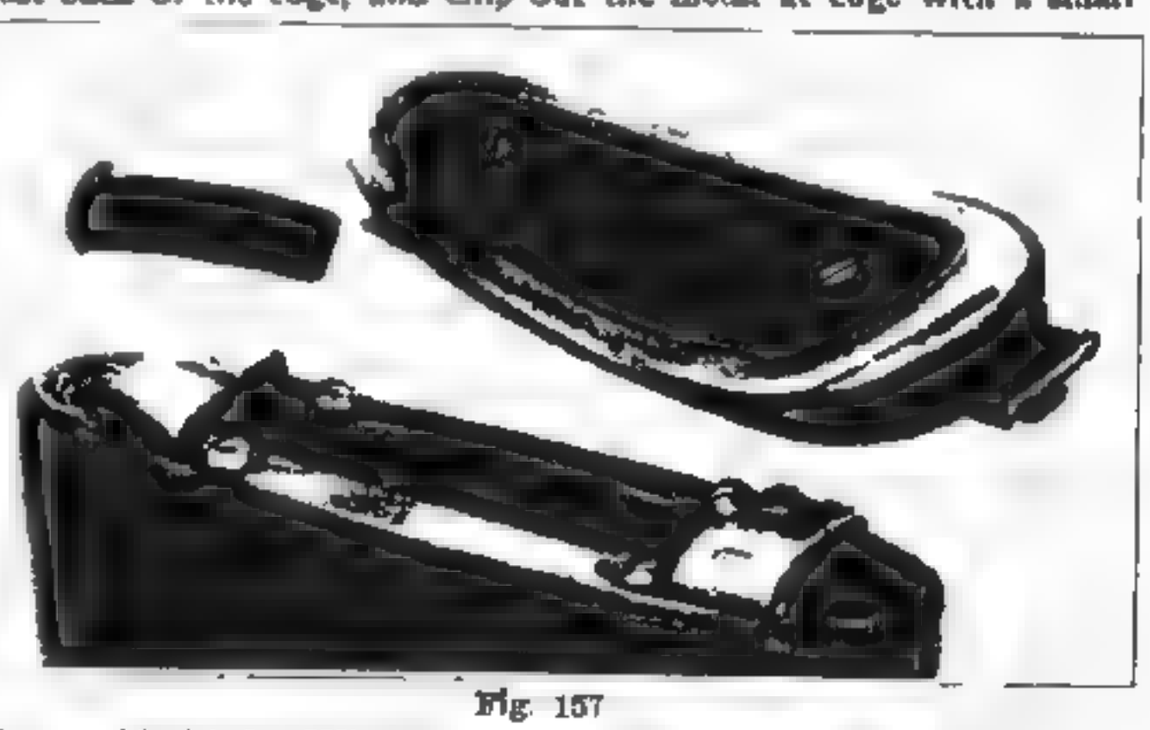

Fig. 157

sharp cold chisel. When the ends of hinge pin are correctly seated in these depressions, the trap is held in place by pressure of the spring.

Figure 157 shows a rather unique method of making the Springfield Sporter buttplate removable, giving access to a hollow in the butt. A slot was cut in each end of the plate with a hacksaw. Into this was fitted a key made of clockspring, bent over short at the outer end. This spring key fitted tightly under the lug brazed to the inner plate which was made of sheet steel 1/16 inch thick. This inner plate was smaller than the butt, permitting the buttplate to set down over it, and the plate was attached to the butt with

several small wood screws. The two screw holes in buttplate were filled with the cut-off heads of the screws, riveted into the holes.

The crank with definite ideas of his own as to what a buttplate should be, will not hesitate to make it by whatever means seem best adapted to the job. One way, if he is skillful at the anvil, is to forge the plate from a bar of steel, shaping it roughly as desired, then grinding and filing to final dimensions. Another way is to

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make up a pattern in soft wood, working out the curves until they suit, and checking the surface with a rather coarse checking tool. This is then sent to a foundry and cast in aluminum. The aluminum pattern may be used, but it is best to use it only as a pattern. With a 3-square file, carefully clean up and sharpen the checking or corrugations; true up the shape, and polish all but the checked area; drill and countersink the screw holes; then send this pattern to an iron foundry for a few malleable castings—they cost little and it's just as easy to get several while you're about it. A little filing and polishing gets the plate ready to blue, and it is exactly the way you want it—not the way some manufacturer thought you should want it. The screw holes can be cast right in the plate, so that they only need to be cleaned up with a rose countersink bit.

Good malleable castings made in the finest of molding sand, are quite as good as drop forgings for articles of this kind. They come out very smooth, requiring a minimum of filing to finish; and they can be blued by heating red hot and dropping into oil, or by the nitre or hot solution processes.

The aluminum pattern is always advisable, as it can be shaped more accurately, and the checking or corrugations worked up better than in wood. Do not make the mistake of making your original wood pattern too thick—remember that iron is heavy and 1/8 inch is plenty thick for the thinnest parts, even counting the metal that will be removed in finishing. Allow only about 1/32 inch in overall dimensions for shrinkage, as this will be slight in small castings.

Remember that ordinary gray iron castings in coarse sand are utterly worthless for this class of work—send your patterns to a foundry equipped to make the best malleable castings and specializing in this work. If you know of some pattern maker, by all means consult with him while making your pattern as he will give you many valuable hints relative to the way the pattern must be removed from the mold, and in what position it will "draw" best—possibly enabling you to avoid wasting an entire job. Good buttplates can be cast in hard brass or bronze, if desired, and finished either in black or in colors.

Figure 158 shows the "free rifle" type of buttplate made of aluminum. The pattern should be made of clear white pine, in two pieces, the "horn" being a separate piece mortised and glued into the buttplate. One may follow pretty much his own fancy as to shape and design, remembering the limitations of the foundry, and the fact that the pattern must be of a shape that can be drawn from the sand. Wooden patterns must be heavily shellaced, and rubbed down with fine sandpaper and oil until very slick, to prevent the sand sticking and crumbling. Unlike cast iron, aluminum and brass castings stand considerable cold bending, so that the horn of this plate can, if necessary, be reshaped a little after finishing, in case you do not get your pattern just right. The rough casting as

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it comes to you from the foundry should be filed smooth and the shape trued up; then polish with aloxite or emery cloth from coarse to fine, then buff to a high polish on cloth buffer with Tripoli compound. The plate may be left bright or it may be blackened as described in Chapter 20.

PALM REST. A buttplate of this type naturally suggests a palm rest for the same rifle. Figure 159 gives details of one that is easy to construct and fit. The ball is a regular water polo ball of solid cork, obtainable in sporting goods stores. Order from the Director of Civilian Marksmanship an extra magazine floor plate, to which the palm rest is attached. Changing floor plates then enables one to use the rifle with or without palm rest as desired. No special instructions are needed for making this rest, as the drawing is self-explanatory. The parts may be made of cold rolled steel, brass, or aluminum.

CUTTING OFF RIFLE OR PISTOL BARRELS. Frequently, due to a damaged muzzle or in order to make an arm light or handier to use, shortening the barrel will be indicated. And there's

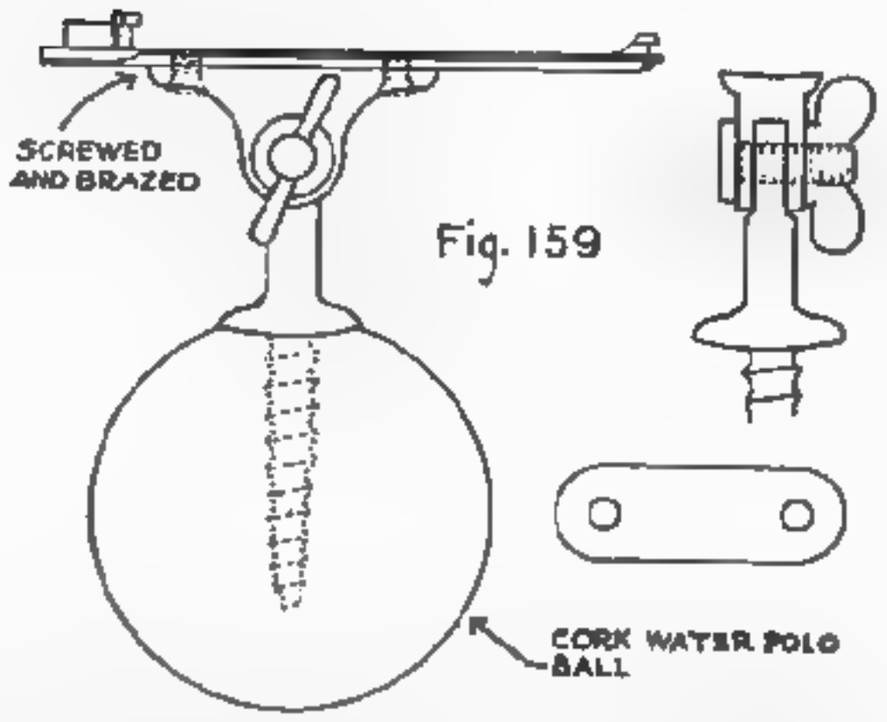

Fig. 159

just about as much bunk prevalent on this subject as you'll find in a day's journey. It isn't necessary to cut off a barrel in a lathe—in fact that is one of the poorest methods, for the parting tool usually leaves a burr on edge of bore which the crowning may not entirely remove. So it becomes necessary to file the muzzle anyhow—why bother with a lathe setup?

Mark the barrel where it is to be cut, and cut it off about 1/32 inch ahead of the mark with a hacksaw. Set barrel upright in the vise, and with a good sharp mill file, dress the muzzle flat and as nearly square as possible. Use an adjustable square if you like, or use only your eye—and don't worry about it not being perfectly

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square. The *edge of bore* will be square all right when you finish the lapping operation to be described.

But first take a countersink reamer and countersink edge of bore to a depth of about 1/32 inch—this is just to get rid of surplus metal, and hasten the lapping.

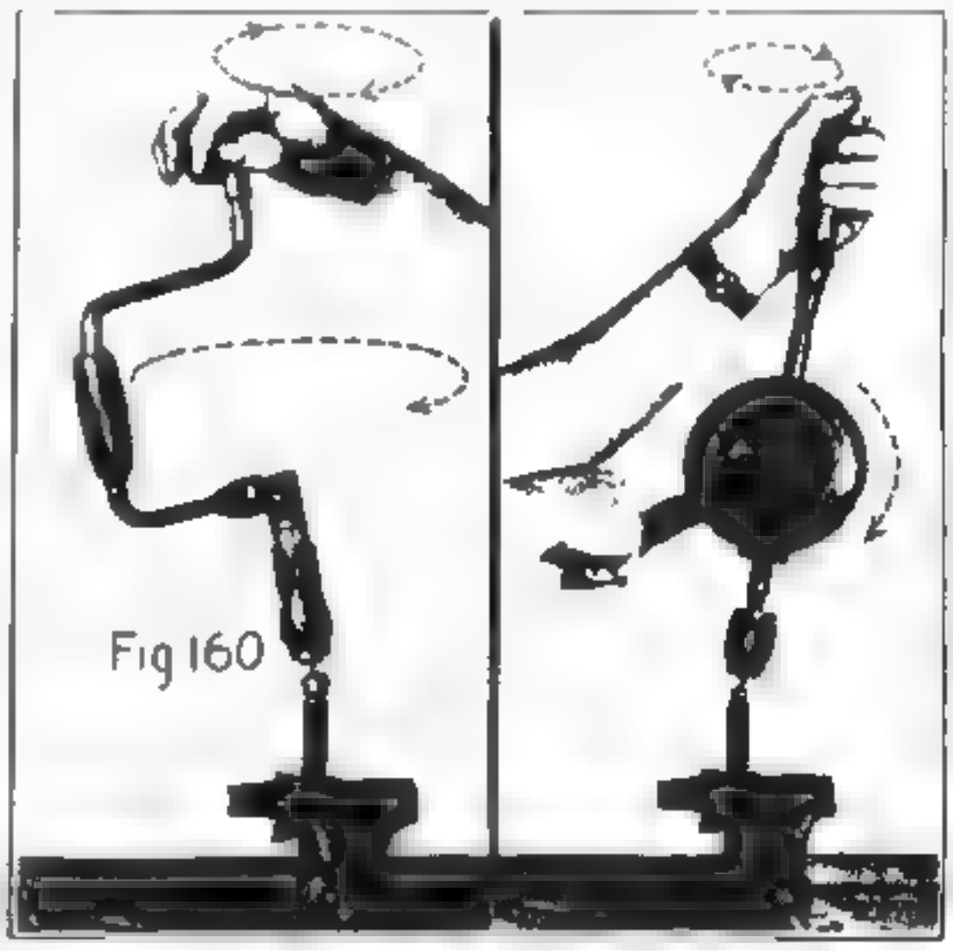

Fig 160

Secure four brass balls measuring respectively 3/8, 1/2, 5/8 and 3/4 inch in diameter. These may be secured from Ellfeldt Hardware & Machinist's Supply Company, at Kansas City, Missouri. I find that these are not regularly stocked by many large supply dealers. Drill about half way through each ball and tap for an 8 x 32 screw, which should be turned in tightly. Cut the head off and use the screw for a shank. Start with the smallest ball. Chuck it in a breast drill or brace, and with a small quantity of valve grinding compound lap the ball into the muzzle as shown in Figure 160, the lapping occurring on the extreme inner edge of bore. Continue with the 1/2 inch ball in the same manner, then with the two larger sizes until the inner half of barrel wall is well rounded. Round off the outer edge with a file to a corresponding shape, then polish the edge, first with No. 00 emery cloth, then crocus cloth held on the ball of thumb.

A muzzle lapped in this manner cannot be otherwise than square—for the simple reason that the surface of a sphere will not touch the

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edge of a cylinder at all points until their axes absolutely coincide—in other words, until the end of cylinder is square

When a number of barrels of the same size and caliber are to be cut off and crowned, a crowning tool may be made as described in Chapter 7. Generally speaking, however, any sort of pilot reamer is a bad thing to put into a muzzle, due to the danger of small particles of grit or cuttings sticking to the pilot and scratching the bore. If you use such a tool, be sure the bore is perfectly clean and lightly oiled, and have the pilot a snug sliding fit.

Do not crown a muzzle too deeply, rounding off the inner edge as at A, Figure 160; leave the edge sharply defined as shown at B.

REPAIRING A DAMAGED BARREL MUZZLE. When the muzzle of any barrel—either rifle, shotgun or pistol barrel—has been damaged by dropping, or otherwise, there is but one known cure—amputation of the damaged portion. Quite often only a quarter inch or so need be cut off; in other cases, two or three inches may be necessary. Sometimes a slight obstruction in the muzzle will cause a bad "ring" or swell which ruins the accuracy of the barrel; when the portion carrying the ring is cut off, the barrel shoots as well as ever. Major Robert H. Lewis was just telling me about an old '95 model Winchester which he used in Texas before entering military service. On his return to the ranch after several years, he ran across the old rifle, rusted and battered, poked away in a shed with other discarded articles. On questioning the major domo, he was informed that the gun "no good—him no hit notting now"—so he took it along and got busy with a stiff cleaning brush, bottle of Hoppe's, and a hacksaw. After cleaning the accumulated rust from the bore he tried a few shots which scattered all over a quarter section, more or less. Inspection showed the rifling all worn out of the muzzle for half an inch back. He cut an inch from the muzzle, crowned it, and proceeded to shoot a 2 inch group at 50 yards. The old gun is still in service on the Lewis ranch near San Antonio, and has many head of game to its credit since the amputation was performed

BENDING TANGS. When remodeling a single shot or other straight grip rifle so that a full pistol grip stock may be fitted, the bending of the tang often looks like a tough job—but it isn't if you go about it right. The action should be completely stripped of all screws, pins, springs—every removable part that will come off. But before doing this make an outline drawing, full size, of the gun "as was," noting by dots and crosses the location of trigger, guard, ends of tangs, tangscrew holes, etc. Then on this same piece of paper lay out the shape you want the new stock to be, so as to show the new position of lower tang, lever, guard, and other parts. If the lower tang is removable, as is the case with the single shot Winchester, it should be removed.

The amateur usually makes his big mistake by bending both tangs.

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Usually the upper tang should be left straight as is, and only the lower one curved to form the grip. Bending down the upper tang reduces the size of the grip, and also makes the comb stick up just that much more above the handhole, when, as a matter of fact, the high comb usually wanted in the new stock is going to stick up more than will look well, without making matters worse by bending down the upper tang.

If desired the lower tang may be heated and bent by careful hammering on an anvil, but as most of them are easily bent cold, I prefer to do it that way. If hard, heat it to a dull red to anneal it; if not hard, proceed without any annealing.

Cut three pieces of round brass rod three inches long and 3/8 inch diameter, and bend one end of each at a right angle, so they will hang on the vise jaws—two on one jaw, and one on the other. Insert the tang between the three rods, so that the single rod is on the inside of the curve to be formed. Tighten the vise, making a slight bend. Loosen the vise, and move the tang or the rods to a different position as required to increase the bend, and again tighten the vise. Continue until you have exactly the curve desired. The tang will be marred very little by this method, and any slight dents may be easily filed out. Cold bending leaves the metal under stresses which must be relieved. Heat the tang to a dull red, and allow it to cool.

Be careful not to make a sharp bend at one of the screw holes—this is very easy to do. A good clean curve is what you are after. Test the shape on the layout sketch previously made until you have it just right.

When the lower tang is not removable it is not always practicable to bend it in the vise. But by setting the receiver firmly in the vise, the two notched steel bars described for bending bolt handles may be used to advantage. Set a thick piece of sheet copper in the notch to prevent marring the tang more than necessary, although a few slight dents cannot be avoided.

When a tang has been so altered it will be found in many instances that it is too long for the grip desired—in that event, simply saw off as much of the lower end as necessary, round it up, and drill a new hole for wood screw to hold the tang in place in the grip.

Very likely this bending will also damage the threaded hole into which the tang screw was originally fitted. The only workmanlike way of getting rid of this defect is to have a first class welder fill up the hole with melted steel, after which you can dress it off smooth by filing. To provide a base for the new tang screw hole, file out a small wedge shaped piece of steel, so that when fitted to position on inside of tang, its surface will be at right angles to the tang screw. Braze or hard-solder this in place, and drill the new screw hole through it. A better method, I believe, is to have the welder, when he fills up the old screw hole, also build up a good

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sized lump of metal on inside of tang in the position of the new hole. This may then be grounded and filed to shape, and the new hole drilled and tapped in it.

FIRING PINS. A common fault of the otherwise excellent low-priced single shot rifles is the frequency with which broken firing pins and faulty extractors occur. Firing pins should be made of drill rod in size equal to the largest diameter of the pin. They must be turned up true so that they will not bind or stick. If you have no lathe, file the pin carefully to shape, leaving it slightly oversize; then hold it in a chuck on the end of your grinder spindle and turn it to final dimensions with a file held against it while turning at top speed.

Flats or notches required in the side of the pin must be carefully filed in by hand, and the easiest way to hold the work is in the same chuck on the grinder spindle; lacking the grinder, check the pin in breast drill, hand drill, or even a tap wrench, which may be held in the vise. This avoids marring the pin with the vise jaws, and holds it in the most convenient position for shaping.

To harden, heat the pin to a bright cherry red and quench in oil; *end*, be sure to heat the thick end first, so that the point may not become overheated. After hardening, polish bright, then heat very carefully to an even blue color and quench in water or oil.

The importance of correct shaping and tempering of firing pins cannot be overestimated. The point must be well rounded—hemispherical—in center fire guns, and slightly rounded or flat for rim fire guns. Even a flat end firing pin must have the sharp edges "eased" off on a stone, and the end must be polished smooth. Mr. Seth Wiard of the Lyman Gunsight Corporation describes an accident which came to his notice when he was with the Remington Arms Company which may serve as a warning:

"The gun in question was of uncertain parentage, being put out under the trade name of one of the large hardware jobbers and upon one occasion, —it is not known whether or not it was the first time since repairs were made—the then owner fired it with a regular medium 12 gauge load. The firing pin drove back into the shooter's eye-ball, entirely destroying the sight of the eye, of course.

"Upon investigation I found that the firing pin was of home-made construction, evidently from some soft material such as a wire nail, and had an exceedingly sharp point. The firing pin was of the conventional type with a notch in the side of the shank so that the nose of the check screw would fit in this notch to prevent its falling out. Examination showed that the firing pin stock, being soft, and the end of the check screw being burred over due to abuse and the point being too sharp, when the gun was fired the sharp point punctured the primer and the gases generated in the shell impinged upon the firing pin point and drove it to the rear in a manner similar to the mechanism used in the Garand semi-automatic shoulder rifle.

"Undoubtedly the firing pin acquired enough momentum through its inertia so that after its travel of the fraction of an inch necessary to bring it back against the check screw, it had enough energy to rub by the check screw and then blew back through the stock."

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The above is but one of many instances that might be related of

serious accidents due to faulty firing pins. The greatest care must be exercised in the development of the firing pin profile, particularly of the point. The shank must fit the hole in frame easily, yet without excess clearance. The pin must be made of good tool steel, polished hardened, and then the temper drawn to a point that will eliminate the possibility of breakage,—which means temper it at blue, which is the right color for all percussion tools. Blue temper in good steel means that the part will batter or dent slightly before it will break, yet it is as hard as is practicable for such work. And be sure the check screw or pin is in first class condition also.

I was about to recommend that a firing pin job should be entrusted to none other than a first class gunsmith; but having seen some gunsmiths who claim, by reason of forty years' experience, to belong in this classification, file out pins from any old piece of scrap that came handy with little attention to shaping, and none to hardening or tempering, I think it's a safe bet that the average amateur, after he has attained reasonable proficiency with tools, is likely to do a better job, once he understands what is required to assure safety and proper functioning.

When the EXTRACTOR of one of these single shot rifles breaks, or becomes otherwise damaged to the point of uselessness, the best plan is to secure a new factory-made extractor if possible. It will require some file fitting, but not a great deal. If the extractor cannot be obtained, make á new one of tool steel, and harden and temper it the same as the firing pin. Blue temper is plenty hard enough. Have the stock for the extractor considerably oversize. Measure the chamber carefully, then drill a hole nearly the same size as chamber in upper end of the stock from which extractor is to be made then ream to exact size. Make a flat counterbore bit with pilot to fit this hole snugly, and counterbore so that the cartridge rim enters easily its full thickness—in other words, so that head of cartridge sets flush with surface of extractor. Then cut away the excess metal leaving upper end of extractor shaped as required, with a round notch which fits the cartridge rim *perfectly*. The balance of the extractor is then filed to shape fitted and finished.

TIGHTENING THE TAKE DOWN ACTION. Many of these old single shot rifles, such as the Stevens Ideal, are takedown, the barrel screwing into the frame, and held in alignment by means of a set-screw under forward end of receiver. After some use the barrel becomes loose in the frame, and accuracy suffers. Remove the barrel and inspect the shallow hole into which the set-screw turns. If the profile of hole is damaged, clean it out and deepen slightly with a new, sharp twist drill or countersink reamer. Then grind or file the point of set-screw so that the taper of point is slightly narrower than the taper in the hole in barrel. Extreme point of set-screw should be blunt or slightly rounded. When shaped so that it holds

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barrel rigid in receiver, harden the set-screw in cyanide. It may develop looseness again after long use, but is easily tightened up again.

SPECIAL SCREWS: Are often easily made by slight alterations to head of an ordinary machine screw. For example, a flat head countersink screw can be changed to oval by turning or filing the head to shape. Sometimes the "special" screw in a gun merely has a smaller head than the standard machine screw. Sometimes beveling the underside of a filister head, to fit a countersink hole, will produce exactly the screw needed. If the screw hole is cut with a bastard thread, and the right screw cannot be obtained, the hole may be reamed and re-threaded for a standard screw. Pinion screws having an unthreaded portion at the point, can be made by turning down the end of a larger screw. And so on.

There are not many times when a spring intended for the one gun will work in another—but sometimes they can be adapted by a little careful filing and reshaping. This applies particularly to old style flat lock springs, and different types of shotgun springs. The few dealers who carry springs in stock usually illustrate them full size in their catalogs, and by carefully comparing the picture with the broken part you want to replace, you can usually select something that will do, in event an exact match is impossible. In that case, choose a number that is slightly larger than the original spring, so that there will be an allowance of metal for fitting.

MAKING SPRINGS. A few words on the subject of forging, filing and finishing flat springs may prove of value, in those rare instances when ready made springs cannot be obtained in the correct shape and size. The plate on opposite page shows a number of flat mainsprings, lever springs and others used in various guns.

If you are not sure of the quality of the steel you are able to purchase, it is safest to use some old tool, such as a file, or a buggy spring, or something which you know is made of good carbon steel. If you are using new bar stock, have it considerably thicker than the finished spring is to be, as steel is often decarbonized for some little distance below the surface in the annealing or rolling operations.

Heat the bar to a medium cherry red for a distance a little greater than the total length of the spring, and forge it all over to "tighten" the fibres and make the structure as compact as possible. Forge it on both edges as well as the flat sides, hammering it out to a trifle more than its finished thickness at the bend. Reheat to good cherry red and bend to a right angle over the square edge of the anvil. The thin metal cools very quickly, so do not try to make the complete bend at one heat, or you will break the fibres; the strength and action of a flat spring depends on the fibres being carried unbroken around the bend. So, reheat, and finish the bend, inserting a thin strip of steel between the two limbs, to provide the necessary space. Note that most springs have from 1/32 to 1/16 inch of width in the crotch, rather than forming a sharp "V."

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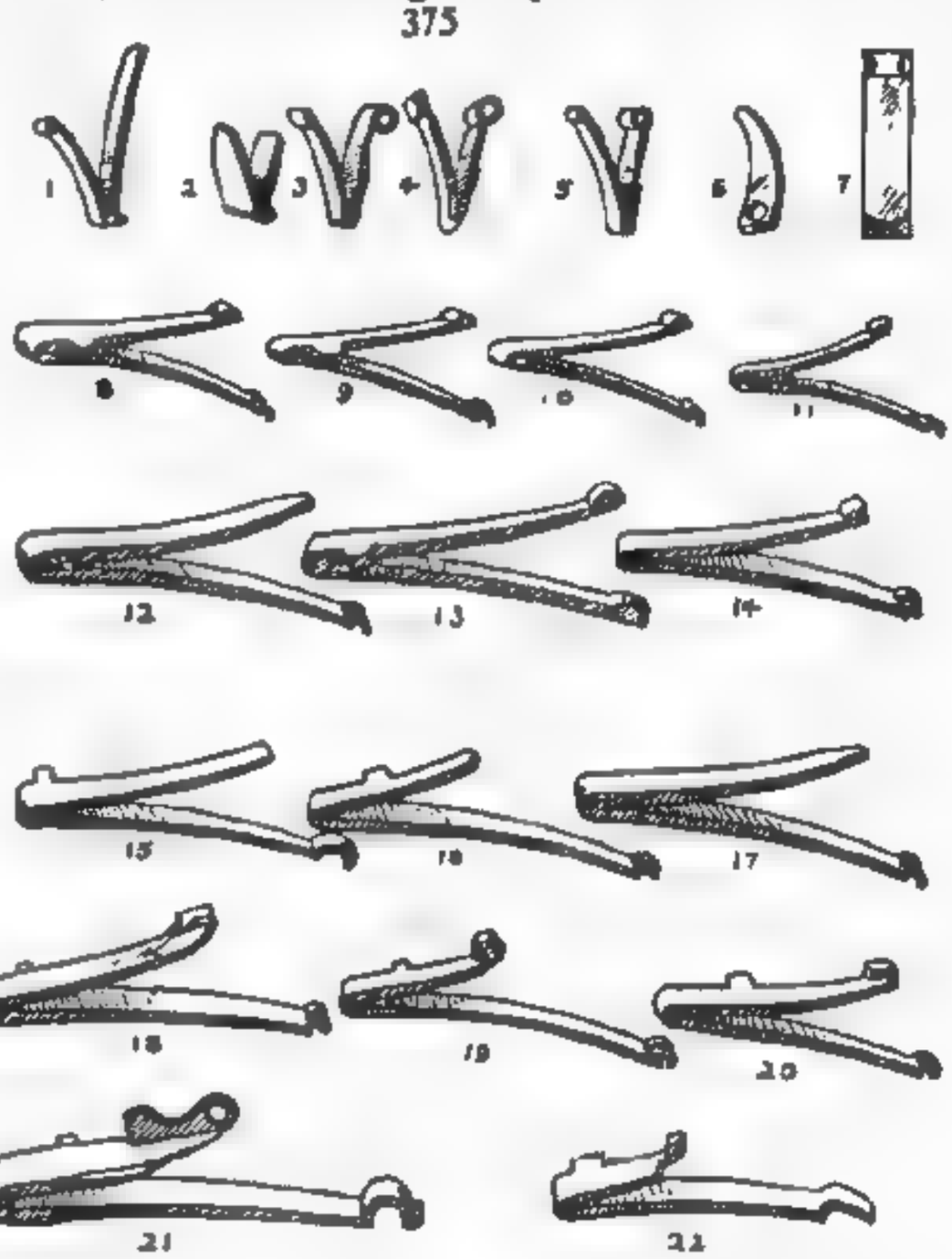

GUN SPRINGS SUPPLIED BY GUS HABICH

Nos. 1 to 7 inclusive: Top Lever Springs. Nos. 1 and 2 for Belgian guns. Nos. 3, 4 and 5 for English guns. No. 6 for Belgian Side Lever. No. 7 for English Side Lever.

Main Springs for Breech Loading Guns. No. 8 Bar Action English or Belgian. No. 9 Bar Action English or Belgian. No. 10 Bar Action, Lock Plates, spring sets back of hammer. No. 11 Bar Action English or Belgian. No. 12 Bank Action, Belgian, one spring, rebounding lock. No. 13 Back Action, English or Belgian. No. 14 Bar Action, English or Belgian.

Main Springs, for Muzzle Loading Guns. No. 15 Back Action Hook, main and sear. No. 16 Back Action Swivel. No. 17 Back Action Swivel, main and sear. No. 18 Springfield Musket Swivel. No. 19 Forward Action, Rifle. No. 20 Bar Action, Gun. No. 21 Springfield Musket, Hook. No. 22 Forward Action Hook, Rifle or Gun.

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The preliminary forging of the bar should have brought the two limbs to nearly their finished thickness, tapering very slightly toward the ends. By no means should a spring be thinner in the bend than it is on the ends—this is the reason so many flat springs break. After forging to as nearly as possible the finished shape, file the spring to exact shape, gradually tapering the thickness toward the ends, and leaving on metal for any studs or projections on the sides.

Some springs have a closed eye formed at the end of one of the limbs. This may be formed by bending the end of the limb over a

rod, or a lump of metal may be left at the proper point in the forging, and the eye drilled after the spring is filed to shape. Use your judgment, from the way the spring functions in the action.

Some springs have a round stud or pin sticking out from the side of the crotch. Do not make the mistake of drilling at this point and driving in the pin—the pin must be made integral with the spring, by leaving the metal wide enough in forging so that the side may be filed away, leaving this pin, which is shaped up with the file. The action of a flat spring comes very largely from the bend, and drilling a hole for a pin at this point will ruin it.

In the forging process, never cool springs in water so that you can go ahead with the finishing. Lay them on the anvil and let them cool in the air.

When finish filing try the spring often for fit, but do not compress it, or it will be bent out of shape. If you have the old broken spring, try the new one beside it for shape and dimensions. When finished, but still a trifle thicker all over than you think it should be, harden and temper as described in Chapter 21. Try the spring very carefully for compression, comparing its strength with the old spring as you recall it. Fit it in place and try the action. Note whether it is sluggish, or quick and snappy. If sluggish, it may have been drawn too much in tempering, or the ends may not be tapered thin enough. The taper should be gradual, and constant from the bend toward each end. File it slowly and carefully, testing frequently in the action. It should cut without difficulty with a good sharp file, but should show its hardness, cutting much more slowly than it did before tempering. If you decide the temper is too soft, heat the spring to a dull red and let it cool in the air, first; then heat to a good cherry red, harden, and temper, drawing less than before. Sometimes two or three attempts on thin springs are necessary before the right temper can be obtained.

The temper will have to be gauged to some extent by the grade of metal used. For example, a spring made of a file must be drawn more than one made of a buggy spring, it being a much higher carbon steel, hence harder before tempering. Extreme care is essential to avoid burning the steel. Never use more than a cherry red heat for both forging and hardening. If the spring becomes nearly white hot—save time by throwing it away and making another.

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CHAPTER 25

HARD FITTING OF SMALL PARTS

WHEN the gunsmith is called upon to fit new factory parts to the mechanism of a gun, he usually finds that such parts are slightly oversize here and there, to allow for variations in size of other parts. Similarly, when making new parts in the shop, they should be left slightly oversize throughout, the file shaping and preliminary polishing leaving them from .001 to .002 oversize. They are then hardened and tempered, or case-hardened, as required, after which the final or "hard" fitting begins.

Factory parts for cheap guns are often not properly hardened. The gunsmith should first fit such parts but leave them a little full at contact points, then harden as already described, and finally hard-fit them.

First, polish the contact surfaces with clean dry emery cloth until bright. Then coat them with a saturated solution of copper sulphate (Blue Vitriol) until a thin copper plating shows. This plating will be so extremely thin as to make no difference in the fitting—its purpose is to show clearly the points to be worked down.

Assemble the new parts in the gun, and work them as required in the action. They may be so oversize that they will not function, or they may merely work "stiff." Remove them, and note carefully the bright spots left on the coppered surfaces. These spots are then carefully and slowly worked down with stones, ranging from fine carborundum to the very finest, smoothest hard Arkansas slips. After each polishing, rub the spot with crocus cloth to remove any trace of oil or grease, and again coat with copper sulphate before trying in the gun.

Hard fitting of action parts requires care and patience—and lots of time. It is this that makes the difference in cost between a cheap gun and a high priced one. Perfect fitting, by eliminating unnecessary play, prevents excessive wear and broken parts. Try the action of a cheap, loosely fitted revolver in comparison with a Colt Officer's Model, or a Smith & Wesson Military Target Model, and you will understand what makes the latter guns worth the difference in cost.

Pick up a $30 machine made shotgun, open the action, then close it slowly. Note the grating together of parts, the ringing of springs, the vicious snap of the top lever as you close the gun.

Now open and close the action of a fine handfinished gun costing $200 or more. Not a sound of friction—no grating of parts together—no ringing of springs—no sharp snap of lever or locking lug; just a soft, mushy, cushioned "thump" as the parts move together—that's what comes of proper hard fitting!

The uninformed hunter may think perfect fitting of parts makes no difference in the shooting qualities of the gun. *It makes all the difference in the world!* For accurate workmanship in one part usually means accurate workmanship throughout. A perfectly fitted lock mechanism is not found on a gun with poorly fitted breech; nor is a well regulated bolt found on a rifle with excessive headspace or poor chambering. The bolt's faults may be concealed under a beautifully chased surface—but the real test of workmanship is the sound of the action when the parts are worked together.

In hard fitting parts of lock and action mechanisms, use care to keep all flat surfaces flat and all edges square and true. Flat surfaced parts should be fitted by placing the parts on the stone and rubbing back and forth without lifting, rolling or tilting them. If working to a definite dimension, set the lock sleeve on the micrometer to this dimension and then try the mike on the part frequently, until it will just slip over every point on the part you are finishing. As you approach the final fit, use only the finest hard Arkansas stone, and polish always in the same direction so far as possible. When trying the parts in the gun, first try them dry, then with a drop or two of clean light oil. Nyoil, Rem-Oil and Marble's Nitro Solvent are all good for oiling closely fitted mechanisms.

As already stated, keep all edges square, and sharp enough to cut. No beveling or rounding off, except to conform to some other part in the gun. When parts are fitted, a few strokes of the finest stone on edges and corners are permissible to take off extreme sharpness.

The final polish, after parts are fully fitted, is given with crocus cloth used dry—and it should be stretched over a flat piece of steel and all flat surfaced parts rubbed on it, rather than rubbing the crocus cloth on the parts. Sometimes inside parts are given a chased finish, as described for rifle bolts in Chapter 18. While this is permissible, and improves the appearance of parts which do not show, the chasing must be done with the very finest abrasive, or the smooth working of the parts will be impaired. A little dust scraped from the surface of a soft Arkansas stone is all the grit that should be used for chasing inside parts.

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Suppose we have a shotgun that has seen better days, and which we want to rejuvenate. After tightening up the hinge joint and breech as described in Chapter 31, we may find we did a little too good a job, so that the barrels, in closing, bear against the standing breech with excessive friction, or perhaps refuse to close completely. Now we may also want to case-harden the frame of this gun, so we will first do a little soft fitting, by carefully polishing out the semi-circular notch in barrel lug, until barrels will close, but are still considerably too tight. Now, after case-hardening the frame by one of the several methods explained in Chapter 22, we next polish off the hinge pin and try again for fit. The case-hardening may have caused some slight warping in the frame which we will now polish out as we do our final fitting. First polish and copper the forward surface of standing breech, also upper surface of action body where breech of barrels rest, should be lightly coated with Prussian blue. Now try to close the barrels, and where they rub against the standing breech, carefully polish off action body with a fine stone. Continue polishing until barrels close readily, but with a snug fit, and to be sure of contact at all points, coat the surface very thinly with Prussian blue. Note also the fit between barrels and action body underneath, and stone off as required. In fitting a breech, a place to watch is the rounded corner between standing breech and forward part of action body—this should be fitted perfectly to lower edge of breech, extractors, etc. Do just as little polishing as possible on end of barrels, as they are soft, and will quickly wear down. The ends should be brightly polished with crocus cloth, also both surfaces of action body; and these surfaces may be given a chased finish.

In remodeling the Springfield and other military and bolt action

rifles, the smooth operation of bolt is of prime importance. The average rifle bolt "as issued"—and as turned out by the factory also—works in the receiver with the pleasing smoothness of a harrow dragged across a cinder pile; while the final raising of the bolt handle often reminds one of trying to pry open an outside cellar door after a rain.

The first thing to remember is that we cannot polish the bolt without reducing it in size—so our work must result in removing as little of the surface as possible, and further, *we must remove no metal whatsoever from the rear end of locking lugs.* If we do, we increase the rifle's headspace, perhaps affecting accuracy, and maybe endangering our own safety.

When a Springfield bolt is finished by Parkerizing, the surface is left dull and somewhat rough, but the finish does not alter the size of the bolt. Parkerizing simply changes the character of the metal at the surface, by changing the steel into a phosphate—in other words, no actual coating occurs. The polishing we do must necessarily reduce the diameter of the bolt, but this slight reduction will make no difference, unless we are grossly negligent.

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The first step, therefore, is to strip the bolt of all parts, including the extractor and extractor-collar. Hold it in the vise, with jaws padded, and with a strip of No. 1/2 carborundum cloth, used with light contact, cross polish it wherever possible, and rub it lengthwise in spots where cross-polishing cannot be done, until the finish has barely been removed, and the bolt is bright. All surfaces of the locking lugs except their rear bearing surfaces may be polished. Now assemble the bolt, leaving off extractor and collar, and coat its entire outer surface (except lugs) with very fine valve-grinding compound, or No. 120 emery and oil. Insert bolt in action and work it back and forth, turning the handle up and down each time. Wash off the grit frequently, and try the bolt dry for smooth working. When you think it runs as freely as it can be made to run in the receiver, wash off all grit, and oil the bolt. Now, place a very small amount of water-mix valve grinding compound on the cocking cam, spreading it evenly with a splinter, and allowing no grit on any other part of bolt. Hold back the trigger, and raise and lower the bolt handle forty or fifty times. Wash out the grit and oil the cam, and try it. The handle should raise much easier than before, but additional working with the grit will continue to improve it.

Sometimes the grit will cause the bolt handle to "freeze" so that it cannot be raised. When this occurs, cock the action by pulling back on cocking piece, wash off the grit, and apply new. When it occurs on a rifle having no cocking piece knob, swear.

Now dismount the bolt completely, and polish all surfaces bright, using No. 00 emery cloth that is nearly worn out, with oil, then use crocus cloth to make it as slippery-smooth all over as possible. Next take a thin, hard Arkansas slip, and carefully polish the edge of cocking cam until it is as smooth as time, work, and patience can make it. With the stone, also polish off the point of cocking piece which runs on this cam. Next polish up the extractor and collar, completely assemble bolt, and you will find it works more smoothly than you ever dreamed a bolt could work. The bolt and extractor may now be chased as described in Chapter 18, but the better plan is to blue it, particularly if used on a hunting rifle.

Do not forget the magazine follower. Unimportant as it seems to the smooth working of the action, it has a lot to do with it. The follower is hard, and should first have the finish rubbed off with carborundum cloth, then the surface polished very bright and slick. If rear end is beveled to make the cut-off inoperative, (See Chapter 30) the beveled edge must be well rounded and polished very smooth. The follower may be buffed with a well rouged cloth buffer, but buffing the bolt will make it very hard to blue.

The foregoing, while referring chiefly to the Springfield, applies equally to almost any other bolt action arm, as well as other types. Pump shotguns that work hard may be wonderfully improved by

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careful polishing of breech block and other parts, particular cam notches in actuating bars, etc., where friction retards the action.

Never change the angle of a cocking cam in the least, or the entire mechanism will be thrown out of "kilter." Neither should the edges be beveled—leave them sharp and square. The one exception is on the cam surface in receiver of the Model 23 Savage sporters, which usually come from the factory with a very short, abrupt slope. The lower point of this slope can be filed down even with upper surface of bolt handle when closed (the metal is not hardened, and files easily), thus greatly easing the cam and causing the bolt to close with about half the pressure originally required. The surface of this cam, after filing, should of course be polished very smooth.

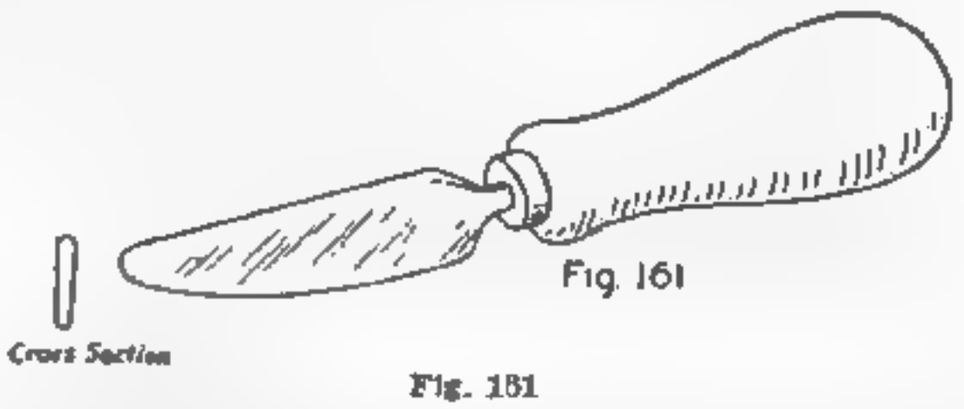

Fig. 161

Fig. 161

If one has unlimited time and desires to carry this polishing of parts to the nth degree, make a burnisher out of an old flat file, as shown in Figure 161. This should be about 2 1/2 inches in length, with the teeth completely ground off all round, taking care not to "burn" the file. The efficiency of a burnisher depends on its extreme hardness. Grind the edges round and polish them very smooth. When you think they can be made no smoother, rake the edge across a piece of soft copper, and note the scratches—then do some more polishing. Nail a thick piece of leather, flesh side up on the bench, rub a little very fine rouge into it, and use this for a strop. Rub the burnisher vigorously on the leather from time to time while using.

To burnish parts, hold them firmly and rub the curved edge of burnisher across the surface with good pressure. Note how the metal takes on a brighter finish, which is perfectly even if you cover every point of the surface as you work. This burnishing smooths the surface and closes the pores of the metal, even making the surface slightly harder. No polishing of any sort with abrasives should be done after a part is burnished.

Chapter 26

CLEANING BORES AND REMOVING OBSTRUCTIONS

I HAVE stated elsewhere that the average shooter who is not entitled to be classed with that ultra super select and specially favored fraternity commonly called "gun-cranks" usually takes his firearm, if any, to the gunsmith to be cleaned; and since in most cases, a considerable period of time has elapsed since the shooting occurred, the gunsmith's inspection of the bore is quite likely to result in rather startling disclosures. Of course the gun "didn't need much cleaning—it was only shot a few times a couple of weeks ago"—but for some unaccountable reason there is, nevertheless a pretty complete coating of red-brown rust running the length of the bore—this is the *least* that can be expected. More than likely there will also be rich deposits of lead, or perhaps metallic fouling in the case of rifles shooting metal jacketed bullets; and it is not impossible that there will be lovely stallactites and stalagmites of rust projecting from the walls of the bore, giving a most charming effect.

For a wonder, however, due to the excellent material used in most American made barrels, the damage is often far less serious than it appears at first glance. While the gunsmith's job is no sinecure, he can as a rule put the barrel back into fairly good shooting condition—although in the eyes of the real crank the bore is ruined.

CLEANING NEGLECTED BORE. The first step, on encountering conditions such as I have described, is to feel out the bore with a bare cleaning rod, removing therefrom any foreign objects that may be encountered, such as broken pieces of cleaning rod or sticks, boot laces, old files, a suit of underwear, or a page from the Scriptures. The uninitiated are likely to resort to almost anything in the line of cleaning material and implements. During the gala days of the world war, when the use of the festive "pull-through" was encouraged in the Marine Corps, it was an axiom

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that if a man insisted on dragging his overcoat through his rifle bore, he should first remove the buttons.

Having ascertained that the barrel is free of such equipment not usually carried in rifle barrels, the next step is to push through a cleaning rod with a common 10 cent brass wire brush on the end. Draw this back and forth several times, and most of the loose rust will be knocked out. After that, the operation depends entirely on conditions as you find them.

Dip the brass brush into Hoppe's No. 9 solvent and scour the bore a few minutes. Wipe out with a flannel patch on the regular cleaning tip, then with another patch saturated with the solvent; then dry thoroughly with dry patches and inspect.

If the barrel was neglected only a day or two and the humidity was low, probably the rust will not have pitted the barrel deeply. In that case give it a good scouring with brass wire brush dipped in solvent; then dip muzzle into a pan of *boiling* hot water and pure white soapsuds, and pump the cleaning rod back and forth with a tight fitting patch on the tip. Continue this until the water coming from the bore no longer shows rust; then rinse with clean boiling water, and dry.

The bore will now probably show some lead or metallic fouling. In the latter instance, remove it in the usual manner, using the standard ammonia dope given in the Appendix if the fouling is heavy, or the regular ammonia swabbing solution if it is merely a light plating.

LEADED BARREL. If the barrel is leaded, plug it at breech, pour in a few ounces of mercury, hold finger over muzzle and tilt and roll barrel about until the mercury has amalgamated with the lead, when it can be poured out and saved for the next case. Afterward, swab the bore with several patches greased with that well known and justly famous preparation known as "blue" or mercurial ointment, then clean out with thin oil or solvent, and dry with clean patches.

Many old time gunsmiths used common vinegar for the removal of lead fouling, although a dilute solution of glacial acetic acid would be even more effective. It is used in the same manner as the metal fouling solution—by plugging the barrel and filling it with the vinegar, leaving it until it stops bubbling; then pour it out and wash bore thoroughly with boiling water, using a brass bristle brush to loosen any adhering flakes of lead. Afterward dry thoroughly and oil.

Now the bore will appear clean, but perhaps slightly roughened by the etching effect of the rust, so a little bore polishing is in order. Winchester Rust Remover or Stazon Rustoff will help its appearance if used with plenty of "Armstrong." If results are not fast enough, try a thin oil, such as Marble's Nitro Solvent, with a little very fine pumice sprinkled on the patch. Renew patches frequently but do not continue this treatment too long. In mild cases of rust

damage, I have used Bon Ami successfully, rubbing an oiled patch on the cake, and using it in the usual manner. This should be followed by polishing with Tripoli rouge scraped off the cake and applied on an oiled patch with plenty of elbow grease; then with rotten stone used in the same manner.

PITTED BORE. If the preliminary scouring with common brass brush does not remove the loose rust, or if the bore seems rather badly pitted and the rust old and hard, try winding on a bit of fine steel wool on the brush. Yes—it will wear the rifle some, and it will round off the sharp edges, too. But not enough that it can be observed with the nude eye, and remember the bore was practically ruined to begin with. Unless the rust can be cleaned out entirely it's no good at all, and drastic treatment in such cases is essential. If the steel wool doesn't help matters, try next a Parker's "Crescent" wire brush made of mild steel wire, dipped in Hoppe's No. 9. If this fails, try a Parker "Dreadnaught" wire brush with either bronze or soft steel bristles, and if results are still lacking, get busy with Parker "Scourer" brush with steel bristles. In my humble opinion, anything that cannot be raked out of a barrel with this last named implement was intended by the good Lord to stay there. The Parker brushes are made in Birmingham, England, and are sold in this country by Paddy O'Hare, 552 Irvington Ave., South Orange, New Jersey. See Figure 162.

Having thus scraped out the rust and thoroughly cleaned and polished the bore, it may still show some roughness by reason of its past wrongs. Before deciding on anything further, measure the bore with a lead slug as described in Chapter 16. If it runs close to the minimum for its caliber, it may be possible to lap it out a half thousandth or so without impairing accuracy in the least. Or, it may be lapped two or three thousandths and its accuracy improved, provided bullets correspondingly larger in size are obtainable. If it appears, however, that lapping will make the bore too large, or if bullets of larger diameter cannot be obtained, better use the barrel as is and be satisfied that it's no worse.

SCOURING OUT OLD BARRELS. Often the crank who derives his pleasure from frequent rounds of the pawn shops and second hand stores in a search for good guns for little money will pick up something really worth while. It is astonishing what splendid shape some old charcoal burner will be in, once the encrusted residue is removed from the bore. Of course one always takes a chance in buying such relics, and it is bad policy to let your delight show in your countenance while the dealer is looking on. But if you want to take a chance, like the well known Steve Brodie and the guy who always orders hash, you'll come out winner about as often as you lose—and maybe oftener.

Before deciding to scrap an old black powder barrel as worthless, plug up the breech and pour it full of boiling water—a quart more

or less according to caliber. Let it soak a few minutes, pour out the water, and refill it again several times. Then get busy with a good wire brush and see what you shall see. If dry crusts show after the first scouring, soak it some more. If they still show, slip a foot or two of rubber tubing over the muzzle, and hold the barrel filled with water over a gas burner until the water boils hard—hold the end of tubing up high to prevent the water running out. A few minutes boiling will loosen a surprising quantity of filth and corruption and other assets of the Republican party—and it won't

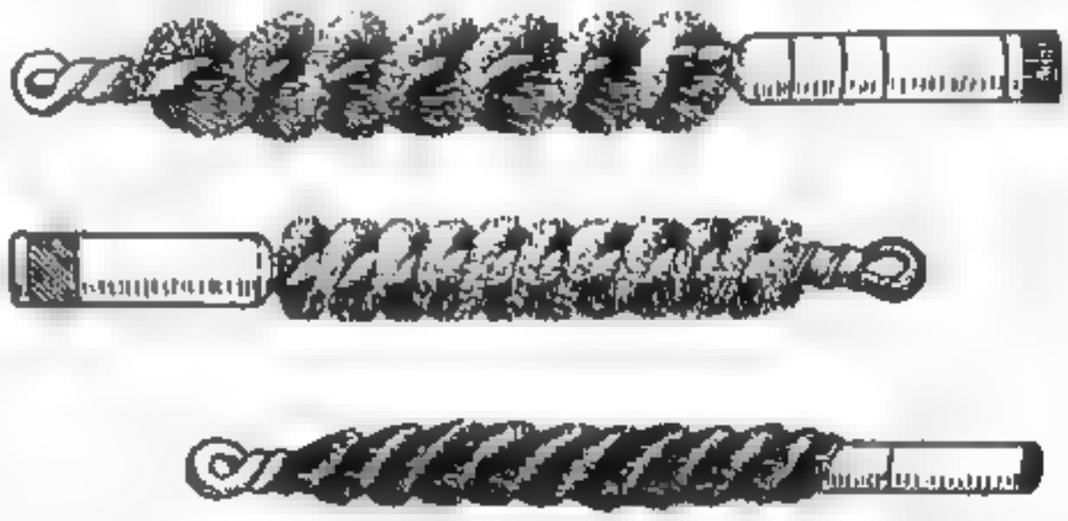

Fig. 162

hurt the barrel a bit. After boiling, scour out again with the brush, clean thoroughly with oil or solvent, dry, and wash in hot water and soap. Then rinse and dry, and swab the bore with the well known pickling solution of 1 part sulphuric acid in 9 parts water. Then rinse again with clean hot water, dry, and oil. Most likely you'll find you've taken the pawnbroker to a first class trimming—which is as it should be.

If the barrel then shows lead, clean it out as already described, and lap the bore if necessary—provided you think it will stand it, or can get bullets the correct size.

SHOTGUN BARRELS. Mighty few men give a shotgun barrel much if any cleaning—and few consider shotgun cleaning sufficiently important to warrant taking the gun to a smith to have the bore cleaned out. It is important, of course, and a shotgun barrel should be kept just as bright and spotless as a rifle or pistol barrel if one wishes to throw an even pattern with a minimum of deformed pellets. When a barrel has been badly neglected it can often be polished out good as new, without seriously altering its shooting qualities—in fact, likely as not the slight enlargement toward the breech may in effect increase the choke and improve the pattern.

A rusty or pitted shotgun should be handled in about the same manner as described in Chapter 31 for overboring. Before rigging up a revolving polisher however, try draw polishing with a good tight

flannel patch coated with grease and No. 120 emery. The other polishing may not be necessary—you can't tell until you try the first method. If the pits are very deep, it may not prove practicable to remove them entirely, for not more than five to eight thousandths enlargement of the bore should be allowed. Better to have the shooting qualities slightly impaired, by a few pits, than ruined entirely by excessive overboring.

Whatever is done, a shotgun barrel should—in fact must—be given a mirror like polish inside, otherwise there will be excessive leading, with poor patterns the inevitable result.

REMOVING BARREL OBSTRUCTIONS. Whelen says there is no excuse for a trained rifleman ever getting an obstruction in the bore of his rifle or any other weapon; yet I seem to have a sneaking recollection of a certain ordnance officer some years ago while hunting in California getting first a foot or so of rich black mud, then a willow switch, lodged as firmly in his rifle barrel as preforordestination in the mind of a Presbyterian; which merely goes to prove that accidents *will* happen in the best of families, and that the infantry wins all the wars.

Anyhow, the fact remains that the removal of various obstructions becomes the frequent duty of both amateur and professional gunsmiths.

The first step in the delivery operation consists of pouring in a liberal quantity of any thin, penetrating oil, and letting it soak for an hour or so, or even over night. If the oil does not run through and out the other end of the bore, pour some in from the other end and let it soak a while. Remove the barrel and clamp it firmly in the vise; then try to push out the obstruction with a square end rod, having a tip like B, Figure 163. If this doesn't start it—and it probably won't—try tapping the rod with hammer or mallet. If this fails, pour in more oil and let it soak a while longer, then heat barrel at the point where obstruction is located, being careful not to get it hot enough to discolor; place it back in the vise and drive out the obstruction with good hard blows. Usually it will come right along with this treatment.

Sometimes a wad of rags will be so tightly wedged that it cannot be driven out, and attempts to do so may ruin the barrel. In such case, braze a two inch wood screw to the end of the rod, grinding off the edge of the screw head smoothly, and pick out the rags. Turn the rod until the screw has a good grip, then yank—and out comes a piece of rag. Keep it up and in time you'll get the entire wardrobe.

There are mighty few cases of CARTRIDGE HEADS BREAKING OFF, leaving the body of the shell in the chamber. When it does occur, however, it's a tough break. As a rule pressures that would so rupture a shell will also expand the brass very tightly in the chamber, making its removal difficult; and, brass that is soft and

weak enough to break will also grip the chamber walls very tightly. Either the Marble or the Ideal broken shell extractor will usually prove effective—and if these fail, make up your mind to go into a real job.

An "Ezy-Out" made by the Cleveland Twist Drill Company is very likely to take hold of that case and get it. But Ezy-Outs are costly tools and you may not have one of the right size available. Another way is to turn up a steel rod a trifle larger than the inside of the case neck—say about 6 thousandths larger. Cut a very fine sharp V thread on it, and screw it tightly into the case neck. Insert a stiff steel rod from the muzzle and drive out the rod, and if the threads hold, the case is likely to come along also.

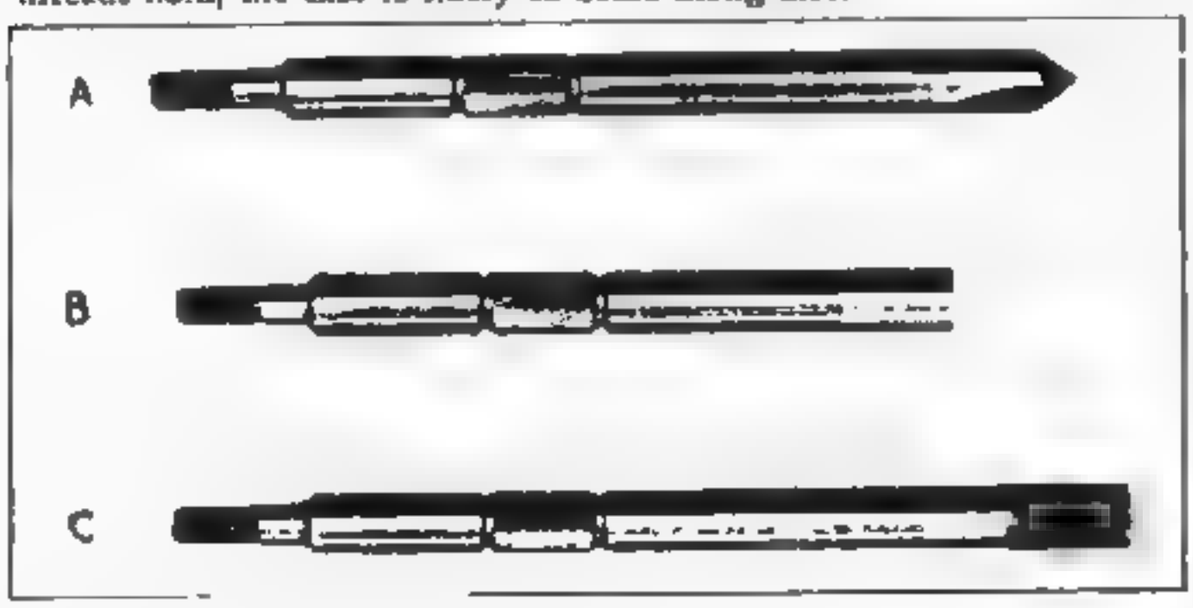

Fig. 163

Another way that is very effective when carefully done is as follows: First scour the inside of case bright with emery cloth wrapped on a small stick. Be careful not to let the emery touch any part of the chamber or bore. Push a small cork or wooden plug well down into the neck of cartridge case, the end of plug projecting about 1/16 inch into the throat of barrel. Coat the inside of case with ammonium chloride (See Chapter 23); then melt up a small quantity of lead and tin solder in a bullet ladle and pour it into the case. Do not fill the case quite full of solder or it will run over the edges and stick to the chamber. In cooling the solder shrinks and draws the brass slightly away from the chamber wall. When hard, insert a rod from the muzzle and drive out case, solder, plug and all.

When a case ruptures at the neck, and the neck is driven partway up into the rifling, it is easily driven out from the muzzle using the square end tip on the rod. The very best tip for this purpose, however, is one shown at Figure 163 C. This is cut as a female to the rifling, the lands of the tip fitting into the grooves in the barrel. These can be procured for .30 caliber rifles only, from the Director

of Civilian Marksmanship. They would have to be made up specially for any other calibers, however.

Figure 163A shows a special cleaning rod tip for boring out a bullet or similar obstruction lodged in a barrel. This should be made by a first class machinist, and the point carefully ground to an exact center. The cylindrical portion should be an easy slip fit in the bore, and the rod should be removed every few turns and the chips cleaned out of the barrel.

A friend recently brought to me two barrels from a 16 ga. Browning Automatic shotgun, with rags stuck in both barrels. He is a man who takes care of his guns, and these barrels had both been carefully cleaned and oiled with some light, very thin oil, and the rags packed loosely in the bore. When he tried to push them out again a few days later, they packed and stuck about the middle of the barrels, and could not be budged in either direction. Using a small mirror to reflect light down the bores showed long streaks of red rust, indicating the cause of the rags sticking. They were removed by pouring in a quantity of "penetrating oil" sold for use on automobile springs, and letting this soak all day, then reversing the barrels and pouring oil in from the other end, and leaving them over night. Boiling water was then poured on the barrels at the point where the rags were wedged; they were then held in a vise, and the rags driven out from the muzzle with a large dowel rod fitting the bore closely. Fortunately the rust had not been in long enough to penetrate deeply, and it was entirely removed without leaving a pit, using a Tomlinson cleaner and plenty of Hoppe's No. 9 solvent, followed by a little oil and crocus on a tight fitting wool swab.

This man could not understand why the barrels had rusted—yet the reason is not hard to locate. The thin bodied oil poured on the rags had partially evaporated, leaving the rags dry in spots. With the barrels so plugged, the air could not circulate through them as it should. Changing temperature in the room overnight caused condensation of moisture within the barrels, and the rags held this moisture in contact with the surface of the metal. Gun barrels should never be plugged up with anything, and only a good heavy bodied oil or grease should be used to protect them.

Chapter 27

LAPPING BARRELS AND BORE POLISHING

LAPPING is an operation involving the cutting of a piece of metal by rubbing it with a softer piece of metal coated with an abrasive. The operation of grinding automobile valves is not lapping, but grinding; for both the valves and the block are of similar hardness, and both are cut by the valve grinding compound. If the valve were made of lead or soft brass, the grit would bed itself in the metal, actually cutting it very little, but would cut the valve seat even faster for that reason.

Lapping a rifle or a pistol barrel involves the casting of a soft lead slug in the barrel; and this slug, when coated with fine abrasive, really becomes an abrading tool, accurately fitted to the bore, and because of its softness and the manner in which the abrasive clings to it without cutting, the lap wears much more slowly than the harder metal of the barrel.

Most rifle barrels are improved by careful lapping. This is not saying, however, that any finished barrel can be thus improved. Because accuracy is to a large extent dependent upon correct bore

diameter and proper bullet fit, and the factory barrel that has been finished to maximum bore size without lapping, might be so enlarged by lapping later on that accuracy would be ruined. The barrel that in process of manufacture is brought to its final diameter by slow, careful lapping, is likely to be a more accurate barrel than one that is not lapped. Having a factory made barrel that fits the bullets tightly, and which does not approach maximum dimensions too closely, one may often improve its shooting qualities materially by lapping just enough to smooth out any faint traces of tool marks, and to remove any tight spots such as are often encountered. But the job must be approached advisedly, and only after careful bore measurements have been taken, as outlined in Chapter 16.

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Even a barrel that runs close to maximum bore diameter may be improved by lapping, provided there are cross reamer marks on the lands—and provided the lapping is carried no further than the removal of these marks, which often result in leading or metal fouling. Again, an old barrel that was tight when first made, may be somewhat worn or pitted from rust; and while lapping the bore smooth will result in this instance in considerable enlargement, careful selection of a tighter fitting bullet will give surprisingly better results. Even an oversize bore may sometimes be lapped out larger and accuracy increased by the use of larger bullets. For example, one may have a Krag that is inaccurate and largely useless by reason of a bore measuring .3095 groove diameter instead of .308 as it should be. By lapping it to .3105 or .311, the .303 British or similar bullets may be used with excellent results, and a rifle that was formerly useless may be made serviceable and accurate. In addition to factory bullets, one may use cast bullets sized to the larger diameter required, or even use them as cast, without sizing, in some instances. The Squib-Miller bullet, for example, will give excellent results in sub-loads in such a barrel, without sizing, and so will the Squibb gas-check bullet.

The equipment needed for barrel lapping consists of a lapping-rod, a small iron pot for melting lead, an Ideal or Bond dipper for pouring, some cotton string or waste, some good light oil, a few ounces of the very finest grade emery flour obtainable, also some fine powdered pumice, fine crocus powder, and powdered rotten stone. Most of these materials will already be on hand in the amateur gunsmith's workshop.

Figure 164 shows details of a lapping rod which is splendidly adapted to the work. The handle assembly involves considerable machine work in the making of the ball bearing ways, and this may be avoided by buying a bicycle front hub and axle complete and brazing or welding the lapping rod to the end of the axle. A handle is then made of wood or metal and attached to the outer shell of the hub by clamp screws, or by brazing or welding if a metal handle is used. A handle made of 3/8" cold rolled rod, bent round the hub and brazed to it is perfectly satisfactory, and is made more comfortable to use by pulling a short piece of thick rubber tubing over each end. Rubber milking machine tubing is excellent for this purpose, as it is thick and soft. The handle must be large enough to grasp with both hands, as considerable force is often necessary in using the rod.

Clean the barrel thoroughly, using ammonia dope to remove any metal fouling, and a wire brush, mercury, or whatever proves necessary to remove leading. Every particle of foreign substance must be removed. Examine the barrel carefully from both ends and mark with chalk on the outside the position of any tight and loose places, rough spots, pits, reamer marks, etc. Measure the

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barrel with a lead slug as previously described, noting the bore and groove diameters carefully, and deciding on the maximum diameters permissible after lapping. After cleaning, swab the barrel with a good light oil, then swab dry with clean patches.

Wrap a bit of cotton string or waste around the lapping rod just back of the tapered jagged tip in the cannelures. Insert rod through barrel from breech, so that tip is an inch or so below the muzzle. Warm the muzzle over a gas burner until it is about as hot as you would have a bullet mold for casting, then quickly set barrel muzzle up in vise and pour in melted lead even with muzzle. This prevents excessive shrinkage and gives a good full lap. When the lead has cooled somewhat, push the lap partway out of muzzle, and file off the fin of lead where it ran over the muzzle, tapering the

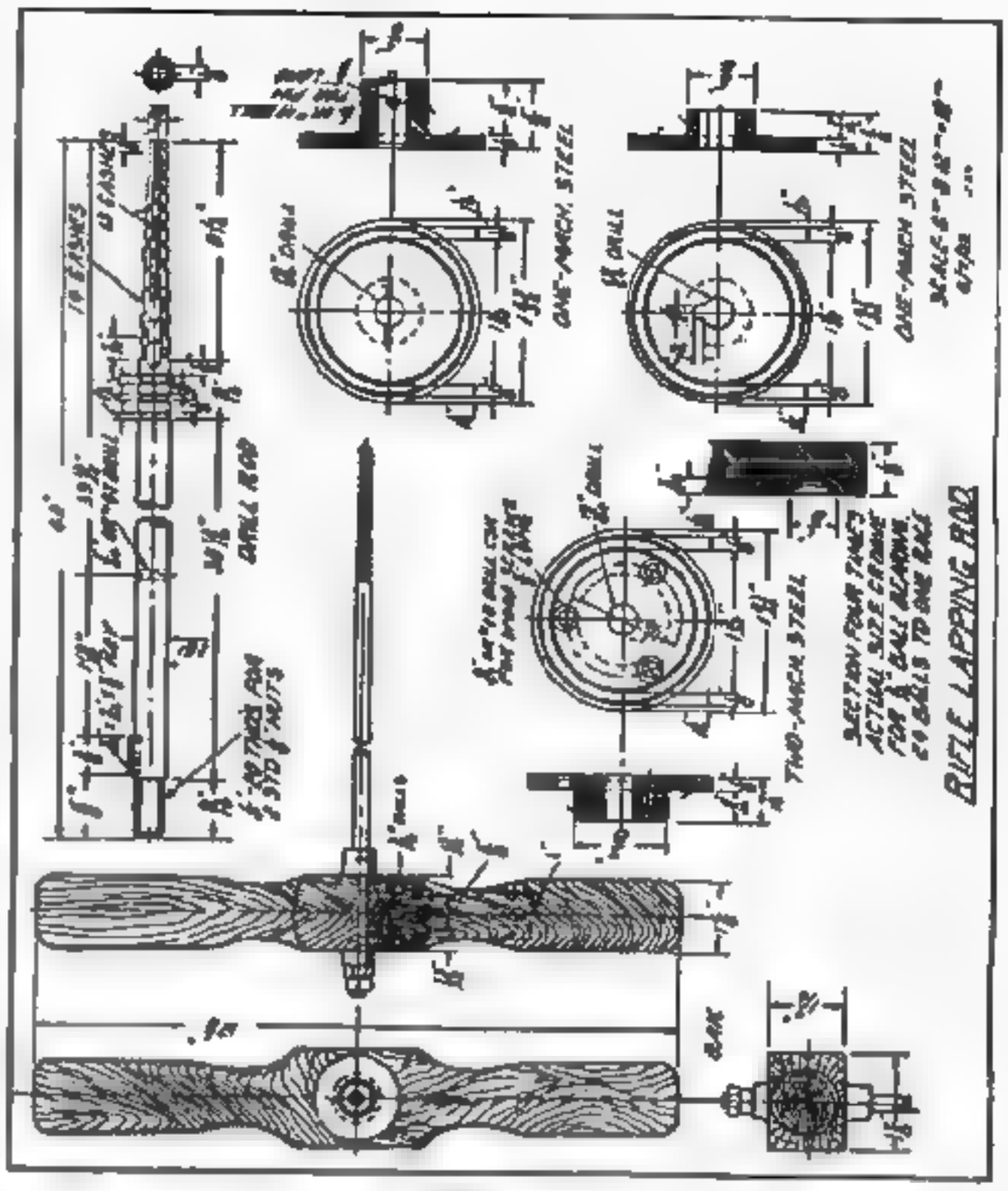

Fig. 164

lap slightly at point. The impression of the lands and grooves should be full and sharp, with very few air holes.

Now, leaving the lap in the barrel, set barrel horizontally in the vise, using brass, leather, or felt padded jaws to prevent marring barrel. Push lap about two-thirds of its length out of the muzzle, and coat it lightly with emery flour mixed with oil. Use lots of oil and very little emery at first. See that the vise is firm and rigid. Grasp the handle and draw rod toward breech with a steady, continuous motion, until the wrapping of string is exposed, as the string should be removed at once. Withdraw the lap partly from breech and coat the rear end also with oil and emery flour. Attach a block of wood well padded with rags about an inch ahead of the muzzle, to act as a stop and prevent the lap being pushed out the muzzle. Then proceed with the lapping, by grasping the handle of rod firmly in both hands, and pushing it back and forth with full barrel length strokes. The lap should project from the muzzle to strike the stop each time, and should also be partly withdrawn from the breech on every back stroke. *But at no time must the lap be entirely withdrawn from the bore,* and if accidentally withdrawn, dip it in the melting pot and melt it off, replace the rod in barrel as in the beginning and cast a new lap.

Rifle bores are like fingerprints and women—no two are exactly alike. Moreover, no two lands or grooves in the same barrel are exactly alike; and while a lap may be replaced to apparently a perfect fit, be assured it does not fit, and the corner of one or more lands is likely to be rounded, or the bottom of a groove made uneven.

This warning may bring forth a smile of derision from certain barrel makers, who, when nobody is looking, are in the habit of using one lap in three or four or half a dozen barrels, inserting it by the feel of the lands, and giving the barrel "a lick and a promise" in the belief that the purchaser will never know the difference anyhow. These fellows may consider such methods as good shop practice, but I don't. In my opinion it's a jackleg system, does no good, often does harm, and it's plain dishonest. That's my story and I'm going to stick to it.

Flour of emery cuts rather fast, and the bore should be carefully watched so as not to lap it too large. However, one is perfectly safe in re-coating the lap with emery and oil three or four times before it is removed for measurement. Then carefully flush out

the bore with kerosene, mop out with a loose patch, then with patches wet with thin gun oil, then dry. Be sure every particle of emery is removed, then measure the bore with a lead slug to ascertain how much the first lapping has enlarged it. If it is desired merely to smooth up the bore, probably one lap will be sufficient.

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If a thousand or so enlargement is desired, three or four laps may be necessary. After considerable lapping the lap becomes loose due to wear, and a new one is necessary.

In lapping a barrel that has tight spots, these spots should be given more work than the rest of the bore. About three short strokes in the tight place, then one or two the full length of the bore, then more short strokes followed by more full length, will gradually bring the bore to the desired diameter. Do not take more than three or four short strokes in the tight place at one time however, as you may make matters worse. One quickly learns to tell by the "feel" of the lap in the bore when the diameter is pretty well equalized.

After removing the tight places always clean out the bore and cast a new lap with which to finish the job, for the lap that removes the tight spot will then be too small. For a perfectly even job a new lap is necessary.

When you are satisfied that the lapping has proceeded far enough, as shown by bore measurements and removal of spots or pits, clean the bore thoroughly and cast a new lap for polishing. First it is permissible to use the finest powdered pumice mixed with oil. This may enlarge the bore a very slight amount, but hardly enough to measure. If the lapping has left it fairly bright and smooth, the pumice may be omitted if desired.

A new lap is again cast in the bore, and crocus powder mixed with oil is used for some time. This cuts practically none at all, but produces a very smooth surface. If crocus powder is not available a little Tripoli or rouge may be used. Scrape it from the stick, mix to a thin paste with oil, and apply a thin coat to the lap. Too much lapping with these polishing mediums is hardly possible, but to play safe, better measure the bore occasionally.

A final lapping with powdered rotten stone and oil may be carried to the limit of your endurance—you can't do too much of it—and the result will be a mirrorlike bore that will scarcely hold lead or metallic fouling under any circumstances. Calcium Phosphate is an excellent bore polishing medium also, and as this is the abrasive used in Pepsodent tooth paste, it is easily obtained. Many riflemen use this paste to remove leading from .22 rifles, as it cuts lead rapidly but breaks down on steel.

Before starting in on any lapping job, the following points should be considered carefully:

Don't attempt the lapping of a barrel unless you have plenty of patience. It will take from two to eight or ten hours to do it right—and this is one job that cannot be rushed. Several days may be employed before you consider the lapping and polishing completed to your satisfaction—remember the job is for yourself—not for the customer of some factory. The cost in material is trivial, and you can't count the cost in time.

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When warming a muzzle before casting a lap, consider the front sight. If attached to a ramp or band that is sweated on with solder, use care to avoid melting the solder. Better warm the barrel, in such case, with rags wrung out of boiling water.

When pouring the lap, maintain a steady stream until the muzzle is *full*. If you stop pouring for an instant the lap may be in two pieces.

Keep a sufficient quantity of lead melted all during the job, and change laps frequently A full tight lap is the secret of a good job.

After two or three strokes the lap runs much easier in the barrel, and one may receive the impression that the abrasive is not cutting —but it is. A lap should be good for five to ten minutes of continuous work with emery flour, and several times that long with the polishing abrasives.

If considerable enlargement of the bore is desired, it will be found practicable to start the job with the finest grade of water-mix valve grinding compound, obtainable from auto supply dealers and garages. Do not use this for more than five minutes, then cast a new lap, and lap with fine emery flour before measuring, as the valve grinding dope leaves a somewhat rougher surface difficult to measure with a lead slug. If the measurement shows more enlargement is needed, use the valve dope again, until within 1/2 thousandth of desired diameter. Then finish with emery flour and the polishing agents.

Stazon Rustoff and Winchester Rust Remover are very good for the first polishing following the final lapping with emery flour.

Always clean out the barrel perfectly clean after each lapping, before casting a new lap, or starting on a finer abrasive.

Clean the lapping rod with oil and wipe dry after each lapping.

Never, under any circumstances, lap a barrel from the muzzle.

Make the lapping rod from tool steel drill rod, of the maximum diameter that will pass easily through the bore. A thin or weak rod will buckle under pressure and rub against the walls of barrel, damaging the rifling.

LAPPING CHAMBERS: Generally speaking, this is a job that should never be attempted either by the amateur or the professional gunsmith, except under unusual circumstances. There are exceptions, however, as will be explained.

A friend of mine procured, at bargain price, a three-barrel gun, the rifle barrel measuring about .303 caliber, but chambered for some sort of "bastard" cartridge which we could neither identify nor locate. The .303 British cartridge would almost—but not quite enter the chamber. A sulphur cast disclosed that the chamber was just slightly smaller than the regular cartridge at the shoulder, the neck and head dimensions being practically the same. Chamber reamers were not available in this caliber, but the following simple expedient proved effective:

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Bullets were pulled from half a dozen new .303 British cartridges, the powder removed and the primers snapped. The heads were drilled and tapped to take the threaded end of a piece of 1/4 inch drill rod 2 inches long. This was then screwed into one of the empty cases, and the other end of the rod squared with a file. Another piece of rod three inches long was chucked in a hand drill, with the projecting end squared, then the two rods connected by a piece of heavy rubber tubing slipped over the ends, giving a flexible connection. Water-mix valve grinding compound was then applied only to the shoulder of the case, which was carefully inserted in the chamber and revolved by turning the drill handle. The drill must be drawn back frequently, and very light pressure used, otherwise the tapered case may "freeze" in the chamber. When the case showed any considerable wear it was discarded and a new one used. Finally, when a case had been lapped in to within 1/32 inch of being fully seated, a new one was used with emery flour and oil, this being lapped in until the action would barely close on an empty case, but requiring excessive pressure. Winchester Rust Remover, pumice and oil, Tripoli and rotton stone were then used in order named until the loaded cartridges just seated correctly. The chamber was very highly polished by this operation, and ejection was perfect. Thus a useless gun was put into service at very small cost, the whole operation not requiring more than an hour and a half.

After the first case had been lapped in, the necks were cut off the other cases to prevent enlarging the neck of chamber, and every time a new case was used the chamber was washed out clean with thin oil.

Unless head-space gauges are available I would not recommend lapping the chamber of any high power rifle using rimless ammunition, as it would be a simple matter to increase head-space to the danger point without realizing it. If attempted, it should only be done with the finest polishing abrasives, and should be carried only far enough to remove any reamer marks and polish the chamber walls. The best plan is to forget it.

Chamber lapping may sometimes be profitably employed in revolver cylinders. It is well known—to handloaders at least—that very often the chambers in one cylinder will vary sufficiently in size so that the case that has been fired in one chamber will not readily enter some of the others. This necessitates full length resizing each time the cases are loaded, and the resulting fatigue greatly shortens the life of the brass.

A sulphur cast should first be made of each chamber, and each cast carefully measured with the micrometer. The operation then is to lap all chambers to the same size as the largest. The same arrangement is used as described for lapping the rifle chamber, except that fired cases are used instead of new ones.

Select the case *fired* in one of the chambers that is about midway in size between the largest and the smallest. Using only emery flour and oil, lap it into the smallest chamber. Then lap into this same chamber the fired case from the largest chamber. By careful selection of fired cases you can lap all chambers to the same size, then cast a lead lap in the largest chamber, and coat it with emery flour and oil, going clear round the cylinder and using this lap three or four revolutions in each. Wash the lap clean—or better, cast a new one, and go the rounds of all chambers using the finer polishing compounds. This simple treatment will result in the fired cases from any chamber fitting all of the others, and will eliminate the tiresome operation of full length resizing entirely. Care must be taken not to enlarge the largest chamber at all—only polishing it with the same lap used in the others to assure all being exactly the

When lapping a cylinder it should of course be removed from the revolver and held with breech end upright in the vise.

The amateur doing his first job of chamber lapping may be tempted to attach the lap to a motor shaft in the hope of speeding up the job. My advice is—*don't*. Lapping of any sort should proceed slowly—and the speed of a handdrill is plenty fast enough—too fast in some instances. And set the drill for its *slowest* speed.

Chapter 28

ADJUSTING TRIGGER PULLS

A JOB frequently required of both amateur and professional gunsmiths is the adjustment, usually for the purpose of lightening and shortening, of the trigger pull. Most rifles, shotguns and pistols as they come from the factory or armory, require such adjustment. Some men have such a perfect sense of touch that they can use a very light pull to advantage; while others need a heavy pull due to a nervous tendency to "loose off" prematurely. The experience of many target and game shooters over a long period of years has shown that the best trigger pull for all round use is one requiring pressure of from 2 1/2 to 4 pounds to discharge the piece. The pull should be clean and crisp without the least suspicion of drag or creep. There should be absolutely no perceptible movement in the trigger until the hammer falls. As the pressure of the finger is gradually increased, the trigger should suddenly release, like the snapping of a thin glass rod.

There is a deal of misinformation in the minds of certain shooters, acquired as a result of the limited training they received during the World War, or later in the Civilian Training Camps. All service rifles, as issued, have long, heavy trigger pulls, with considerable creep on the final take-up. Plainly it is impossible to give these rifles the fine adjustment which the individual bestows on his own gun. So the rank and file are taught to overcome this mechanical defect by slowly squeezing out this final drag when firing on the range—in other words, they are taught to endure what cannot conveniently be cured.

In every walk of life there is a large percentage who have never learned, and never will learn, to think for themselves; and these brethren will stand up and tell you they like a pull with plenty of creep in it, because that's the kind of pull they had on their rifle at

Camp Whoozis last summer which they were told was "the best rifle in the world," and moreover the range instructor told them to squeeze it off gradually, so they wouldn't know when the piece was going off, etc., etc., etc. What a sorry thing is a little learning!

TRIGGER ACTIONS. Triggers, both from the standpoint of their mechanism, and their action under the impulse of the trigger finger, are divided into three classes—(1), The Plain Trigger, (2), The Bolt Action Trigger, and (3), The Set Trigger—the last named being divided into sub-classes, the Single Set and the Double Set.

Before going further into the matter of reducing trigger pulls, let us understand thoroughly the nomenclature of trigger mechanisms. These usually consist of three essential parts, not including springs, viz., the hammer, the sear, and the trigger. In bolt actions, and in some hammerless guns, the "hammer" is replaced by a cocking piece, a striker, or plunger actuated by a heavy spring—all of which may be temporarily considered as "hammers" for purposes of explanation. The hammer is held in the cocked position by the sear engaging in a notch. The sear may be a separate part, or it may be the upper end of the trigger itself.

In the plain trigger which has the sear made integral, the trigger is pivoted by means of a pin or screw between the upper end which forms the sear, and the lower end to which the pressure is applied by the finger. Thus, the trigger becomes a lever of the first class, the tension formed by pressure of the hammer notch on sear forming the "weight;" the pivot in pin or screw forming the "fulcrum," while the finger supplies the "power" at the lower end.

When a separate sear is interposed between trigger and hammer, a double system of leverage is formed, and the trigger is usually a lever of the second class, i. e., with the weight located between the fulcrum and the power—the weight in this instance still being supplied by the pressure of the hammer, and transmitted to the trigger through the sear. The sear may be a lever of either the first or second class, according to the design of the mechanism.

Figure 165 illustrates the three types of levers known to physics. In a lever of the first class, it will be evident that if the fulcrum is located midway between the weight and the power, the power required must be equal to the weight. Consequently, were a trigger designed in this manner, that is pivoted midway between the point of the sear and the point where the finger presses in firing, the finger would have to supply a pressure greater than that exerted by the hammer. Now the pressure of a stiff hammer spring, stiff enough to assure against misfires, is considerable. (Try cocking your rifle by means of weights suspended from the hammer or cocking piece). Such a pull would not be conducive to good shooting, to say the least; so, the required "power" or finger pressure is reduced by locating the trigger pivot much nearer the sear point than to the finger point.

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But in physics, nothing is gained without some loss. The nearer we move the pivot toward the sear point, the less power is required to fire the gun, but the movement, the travel, of the lower end of the trigger, is increased in direct ratio. Likewise, the shorter the distance the sear must move before it is released from the hammer notch—or, putting it inversely, the less support the hammer receives from the sear.

ADJUSTING "HAMMER ACTION" TRIGGERS. Taking it by and large, the *average* man, woman or child is a fool with

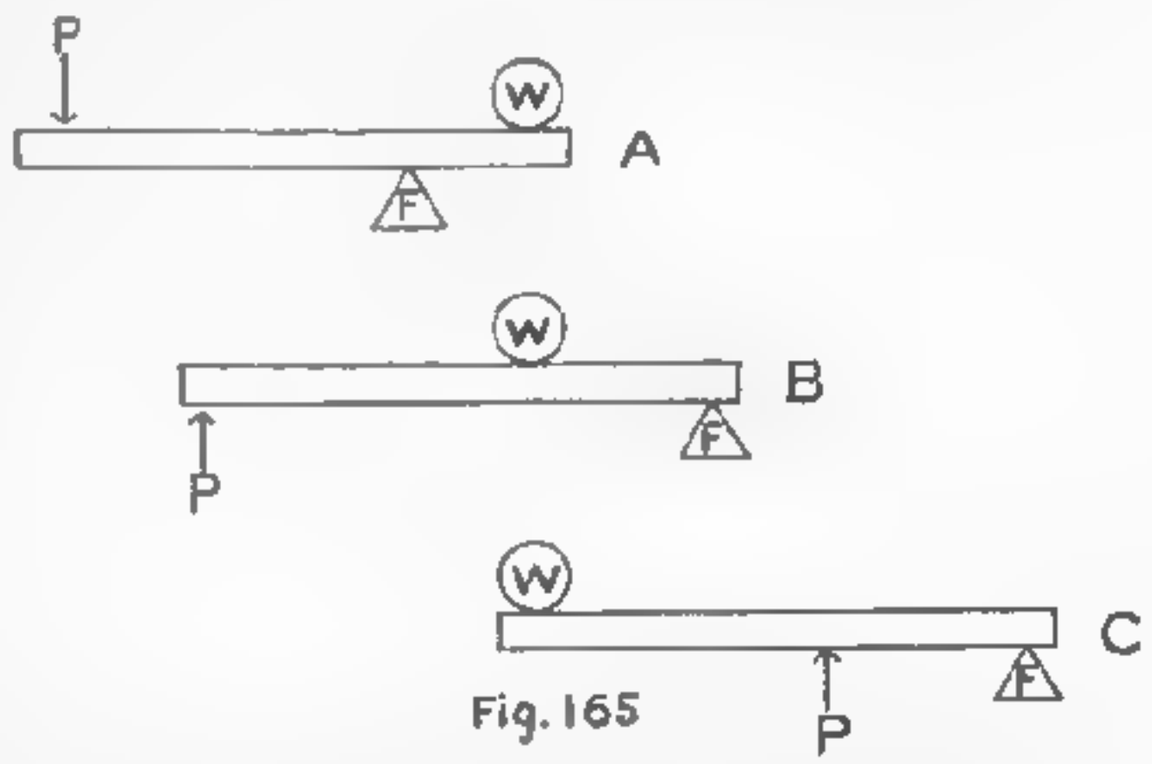

Fig. 165

a gun, and so the factories, making their guns to be sold to this average man, woman or child, must increase the safety factor as much as possible by making the gun reasonably hard to discharge by accident. So the hammer notch is cut much deeper than necessary, and deeper than it would be cut, could the factory but know that the person using the gun is an expert with firearms. A gun must not discharge itself by a sudden jar, such as dropping the butt upon the ground, so the hammer must be well supported by the full width of the sear nose; and the leverage of the trigger must be increased. This in effect, magnifies to the finger the travel of the sear point on the hammer notch, hence the creep or drag. Our problem is twofold: to reduce the finger pressure required within the desired limit of 2 1/2 to 4 pounds; and to eliminate the perceptible creep.

To accomplish this, several things may be necessary. Plainly, we

cannot move the trigger pivot closer to the sear point to increase the leverage and reduce the necessary power. Our first step, therefore, is to study carefully the shape of the sear point, and its relation to the hammer notch. Figure 166 "A" shows the angle of the hammer

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notch as most rifles come from the factory. Here is a very heavy trigger pull—heavy because when the trigger is squeezed, the sear in its forward travel against the hammer notch has to cam the hammer back somewhat, before it is clear; it is operating against the full force of the mainspring under tension. Now if we reshape the hammer notch like "B," in Figure 166, so that the sear point and the surface of the notch bearing against it are exactly parallel, and at right angles to a line from the trigger pivot to sear point, our pull is greatly reduced—for in squeezing the trigger we do not increase the pressure of the hammer against it.

The amateur will often make the dangerous mistake illustrated at "C," Figure 166. Beveling the hammer notch in this manner permits the hammer to cam the sear forward until it is clear. Naturally

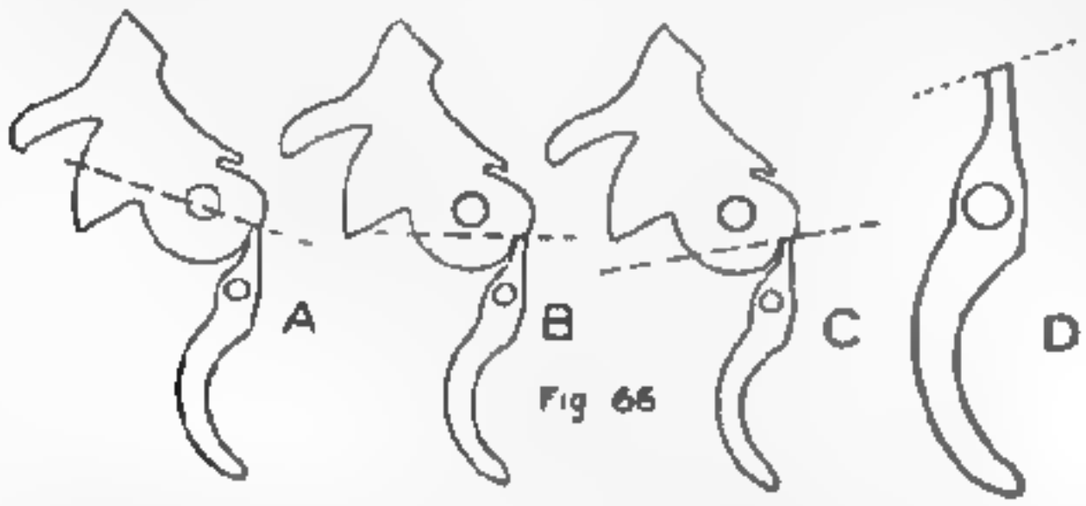

Fig 66

the gun can be fired with the slightest pressure—and quite often it will fire itself with no pressure at all. The slightest jar may result in accidental discharge.

Going back to "B," Figure 166, it is evident that while reshaping the hammer notch has reduced the pressure required, it has not reduced the length of the pull—in other words, the creep. The first step in accomplishing this consists of polishing both the hammer notch and the point of the sear with a hard Arkansas slip hone as shown in Figure 167. In this polishing a *very* slight beveling of the hammer notch is permissible, but it should be so little that the eye cannot see it. A jeweler's magnifying glass with a 3 inch focus is indispensable for use in adjusting trigger pulls—a true perception of the shape of a very small notch is not possible with the naked eye.

Before changing the shape of the hammer notch in the least, however, it is well to polish it with the slip hone and note the effect on the pull. Often this polishing is all that is required, depending on the weight of the hammer spring. Watch the hammer as you squeeze it off; and if the sear is forcing it back a trifle as you squeeze, this will readily be seen as well as felt. In that event, changing the angle of hammer notch will almost surely be necessary.

For changing the notch, I prefer to use a small file. A 6 inch

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American-Swiss Pillar file 1/8 inch wide, with No. 3 (super smooth) teeth is just right for this job. The edges are square and sharp, and there are no teeth on the edges. This file will cut even quite hard steel, and its use permits more accurate shaping than does the stone. Many hammers, particularly in the cheaper arms, do not appear to have been hardened at all. When a soft one is encountered, it is best to shape it up with the file, then case-harden both hammer and sear as explained in Chapter 22 then finish the work on trigger pull with the slip hone.

As already stated, the sear point should be square, and its surface parallel to the surface of hammer notch. You may find on a new rifle that the sear point has no regular shape at all, being carelessly and unevenly beveled or rounded. Two or three light strokes with the pillar file will give a flat surface at the correct angle, after which it should be case-hardened at the point only, and final fitting done with the hone.

Before the final polishing, assemble the parts and try them by snapping the trigger quickly while pressing the hammer forward hard with the thumb. This will show you a bright mark on hammer notch where the sear point pressed. This pressure should be equal the full width of the notch—but you may find only a narrow bright

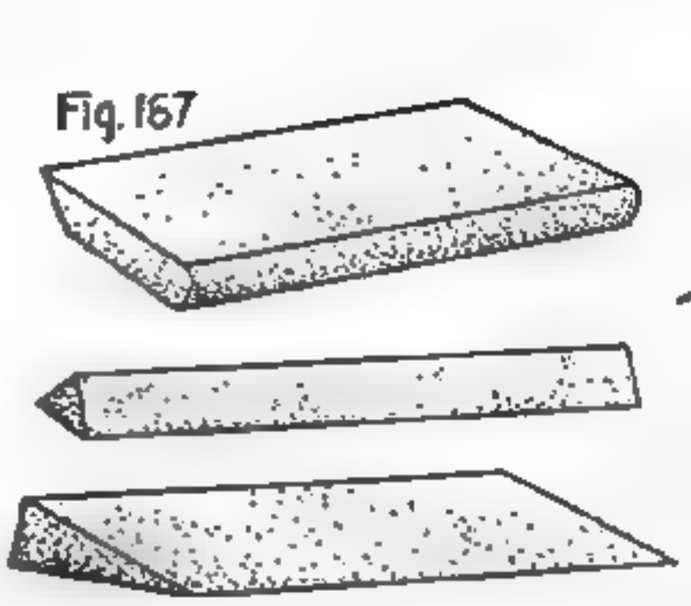
Fig. 167

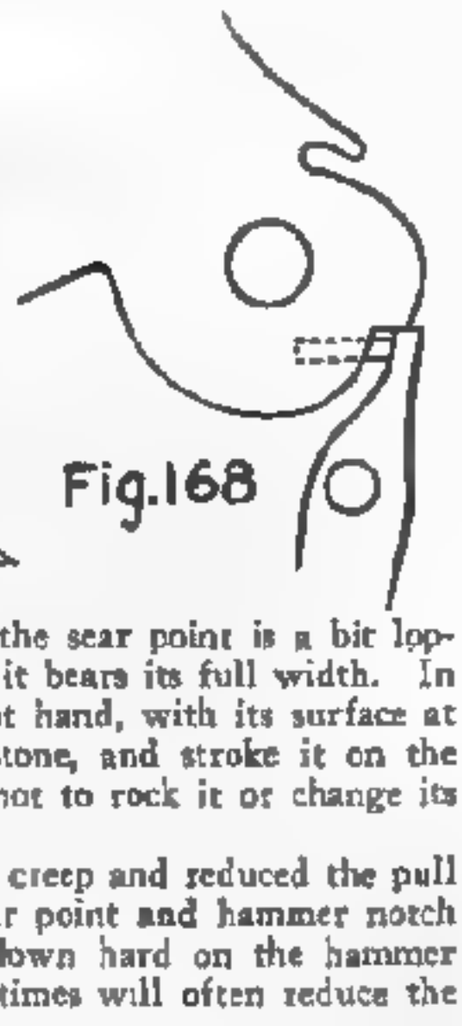
Fig.168

streak on one side. This indicates that the sear point is a bit lopsided, and it must be dressed down until it bears its full width. In honing the sear point, hold it in the right hand, with its surface at the proper angle resting on a small oilstone, and stroke it on the stone in one direction only, taking care not to rock it or change its position.

If this polishing has not eliminated the creep and reduced the pull to the desired weight, try burnishing sear point and hammer notch by snapping the trigger while pushing down hard on the hammer to increase the pressure. Two or three times will often reduce the

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pull as much as a pound. However, the creep may still be there, indicating too long a travel of the sear in hammer notch, or in other words, too deep a notch.

At this point the inexperienced is likely to make one of two serious mistakes—or perhaps both. He may file the sear thinner, or he may make the hammer notch shallower, by filing or grinding off its front edge. *Both methods are wrong.* A moment's reflection will show that reducing the thickness of the sear has no effect whatsoever, because it does not change the travel *of the rear edge of sear point to front edge of hammer notch.* Filing off the front edge of hammer notch will undoubtedly eliminate the creep, and give a very quick pull; but it will also prevent the sear from moving forward sufficiently to clear the safety or half-cock notch as the hammer falls, and this notch striking the sear point either breaks or mutilates the sear, or else breaks off the safety notch. The thing to do is to polish and round off, *very slightly,* the rear edge of the sear point, but do not round the edge of hammer notch any more than is necessary to take off the burr and leave it smooth. This edge must be distinct and sharp.

It is a mistake also to bevel back the point of sear sharply, as in "D," Figure 166, for while this causes the hammer to fall at the slightest movement of the sear, the hammer in falling cams the sear forward sharply, causing the trigger to jump back away from the finger with considerable disturbance to the aim. The finger should have perfect contact with the trigger before, during and after the hammer fall.

When none of these methods bring the required freedom from creep, excessive depth of the hammer notch is undoubtedly the cause, and "pinning" the hammer is indicated. Pinning is a simple and sure method, and is permanent. Figure 168 shows the result. A 1/16 inch hole is drilled in hammer just below the notch, and a pin made of drill rod driven into the hole. File off this pin a little at a time, until the sear is permitted to engage the hammer notch just the right depth to give a clean, crisp pull, but deep enough so that the hammer cannot be jarred off. To test for safety, cock the gun and hold at the point of balance in the left hand, and strike butt smartly on all sides with the right hand. If it is possible to jar off by any means whatsoever, file off the pin a little more, even at the expense of smoothness of pull. Safety is the prime consideration—*always.*

The foregoing instructions apply to all guns having inside or outside hammers, whether the sear is made integral with the trigger, or as a separate part. The sears in shotgun locks usually operate in very shallow notches, so that a little careful polishing is all that is needed to give the required pull. Remember that most shotgun safeties merely lock the triggers, and not the sears, which may be readily jarred off if the pull is reduced too much.

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After lightening up the triggers of a double shotgun, and before taking the gun afield, load one barrel and fire it with both barrels cocked—and note carefully whether the jar of discharge knocked off the other lock. Then load the other barrel and make a similar test. Then load both barrels and fire them singly several times to be sure. "Doubling" in a shotgun is not looked upon with favor—and it is very easy to cause a gun to double if the triggers are too light.

The same applies to the automatic shotgun. When you think the pull is right, load one shell into chamber and one in magazine, and fire the gun. Test in this manner several times, and if the gun ever fires more than one shot to each pull of the trigger, *make the pull heavier*.

Similar tests should also be applied to any automatic rifle or pistol.

While on the subject of trigger and hammer mechanisms, a few comments on specific jobs may be in order. Word seems to have gone forth that it is nearly impossible to reduce the creep in the '73 model Springfield action, due to its stiff mainspring and big heavy hammer, and the margin of safety they necessitated. This pull may be improved materially by careful honing of the sear point and hammer notch; and it may be made as fine as any on earth by a simple method which I used when remodeling the Springfield .45-70 illustrated in Chapter 30. When inletting the action into the new stock, the guard and trigger plate was set about 3/16 inch forward of its original position. This caused the upper end of trigger to come clear of the rear end of sear, so that pulling the trigger did not fire the gun. The trigger was then removed, and its upper end heated and drawn out by hammering until about 1/8 inch longer, when it engaged the sear and the change in leverage greatly reduced the length of pull, eliminating practically all creep. However, changing the leverage increased the finger pressure required, and this was reduced by carefully honing and polishing sear point and hammer notch, the final pull being 3 3/4 pounds, and without any creep.

Setting the guard forward of its normal position of course threw the tang screw hole out of register. This made no difference, however, because the upper tang which is attached to the breech plug, was lengthened by welding on a piece of tool steel, so as to form a base for a Lyman No. 103 sight—the one supplied for use on the '99 model Savage. When welding on this tang extension the original tang screw hole was welded up at the same time, and a new hole drilled 3/16 inch forward of the old one, to register with the new location of the guard.

Most pump and automatic shotguns of the "hammerless" persuasion really have a hammer located within the breech action; and the process of reducing the trigger pull is fundamentally the same as on outside hammers. Care must be exercised, however, not to get the pull too light, particularly on automatics, as the jar caused

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by functioning of the action may cause the hammer to fall voluntarily, making a machine gun of your favorite fowling piece!

This applies also—and even more so—to all makes and models of AUTOMATIC PISTOLS. Due to the distance of the trigger from hammer in this type of arm, and the necessary bars and links connecting the parts, it is not possible to eliminate all of the creep. Very careful honing of the hammer notch and sear point will bring the pull on most automatics to between 4 1/2 and 6 pounds—and this is about as light as one should try for. The Colt factory, when specially requested to do so, puts the best pull on their .22 Automatic that I have ever seen on any automatic pistol, and it will pay anyone owning this splendid little arm to avail themselves of the opportunity of having the pull adjusted at the factory. My own pet when it comes to trigger pulls is the .45 Colt Auto. I can work this down until it suits me a lot better than the best factory job I have been able to get, although it is not safe to try to eliminate all of the creep, or the gun may empty itself on the first squeeze. I have less success on other automatics, as there seems to be a knack in the matter, the cause of which I have not discovered.

TARGET REVOLVERS may well have lighter trigger pulls, the U. S. R. A. allowing a minimum pull of 2 1/2 pounds in the "Any Revolver" Match, while the minimum for single shot pistols is 2 pounds, and for military and pocket revolvers is 4 pounds.

The danger in reducing the pull of a double action revolver lies in the possibility of dressing down the forward edge of the hammer notch, permitting the point of trigger to slip between the point of sear and hammer at the instant of firing. This may result in failure of the arm to function, and in broken parts also. Major Hatcher gives some splendid "dope" on revolver trigger pulls in this book "Pistols and Revolvers" and this, as well as all the rest of the book, should be carefully studied by all hand-gun devotees.

On many arms the trigger has an unnecessarily long travel rearward after the hammer has been released. Thus, the finger is jarred and the aim disturbed by this back "slam" of the trigger at the instant of firing. This fault can easily be eliminated by drilling a small hole in the trigger and screwing in a steel pin projecting to the rear. This pin is filed so that it stops the trigger's back movement at the point of release. Another method is to drill the rear of the guard and screw in a pin against which the trigger strikes after releasing the hammer.

Sometimes it is difficult, when reshaping a sear point and hammer notch in order to lighten the trigger pull, to visualize the exact position of the parts as they stand in the action, so as to decide on what is the correct angle of hammer notch. Much time may be saved and trouble avoided as follows: Take a piece of brass or other easily drilled metal plate a quarter inch or so in thickness, and drill holes corresponding exactly to the hammer, sear and trigger

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screw or pin holes in the receiver. This may be done by clamping the metal plate to the receiver and drilling through the holes in some instances; or it may be done by careful divided measurements taken from centers of holes in receiver. Into these holes in the plate, drive steel pins that will just fit the hole in hammer, trigger and sear. The parts are then set in place on these pins, so that their action is readily observed, giving the workman a true understanding of just how they stand in relation to each other in the action; and he can see at a glance the best angle to cut the hammer notch, and the best way to shape the sear point for best results. Moreover, he can actually test the pull while the parts are on this plate, by placing hammer in cocked position, with sear point in notch, and pushing against hammer spur while pulling back on trigger. This will save assembling the action parts many times, only one or two trials being necessary for final adjustment.

SET TRIGGERS, both single and double, are usually very finely adjusted by the maker, and the best thing to do with them is to let them alone. A set trigger is really a combination of a trigger and a small hammer, the trigger when released, allowing the hammer or "striker" to rise and strike the sear in the action a quick blow, releasing the hammer proper. Sometimes one will find that set trigger parts, particularly in some of the cheaper imported weapons, are not properly hardened, and the notches in a short time wear until they will not hold. Such a mechanism is both annoying and dangerous. The mechanism should be dismounted and all parts except springs carefully case-hardened, following instructions laid down in Chapter 22, then the notches and points may be carefully honed, and the pull will "stand up."

Almost all set triggers have a small screw by means of which the pull may be lightened or increased. A common fault is that this screw, not being hardened, soon wears loose in its hole, and the tension varies. Sometimes it is possible to find a screw having a similar thread which runs a bit oversize, giving a tight fit in the hole. The new screw and the trigger plate should then both be well hardened with cyanide, the screw ground to correct length, and little if any difficulty will then be encountered. When a new screw cannot be obtained, dismount the set trigger mechanism, and with a small ball peen hammer peen around the screw hole close to the edges, but not so as to batter the edges. Careful work will reduce the hole sufficiently to make the screw fit tightly, after which both screw and plate should be hardened.

BOLT ACTION RIFLES require an entirely different trigger action from the hammer or hammerless types. Here the hammer is replaced by a cocking piece, and there is no half-cock. When the bolt is forced forward and shut, (a very quick and forcible operation, as a rule) the cocking piece comes hard against the sear, as in Figure 169, and the contact surfaces of the two must be large and strong

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to stand wear, and to prevent the cocking piece by any chance slipping by the sear and firing the arm while the bolt is being closed. So the sear must engage the surface of the cocking piece notch for about 1/8 inch at least, for safety; and obviously, this means a painfully long

drag in the trigger pull.

Now study Figure 170, which is a Springfield trigger and sear, and is typical of all bolt action trigger mechanisms. Here we have a lever of the second class, the weight being located between the fulcrum and the power. The two projections "a" and "b" form two fulcrums. When the trigger is first squeezed, that is, on the preliminary pull or "take-up" fulcrum "a" bears against the under-

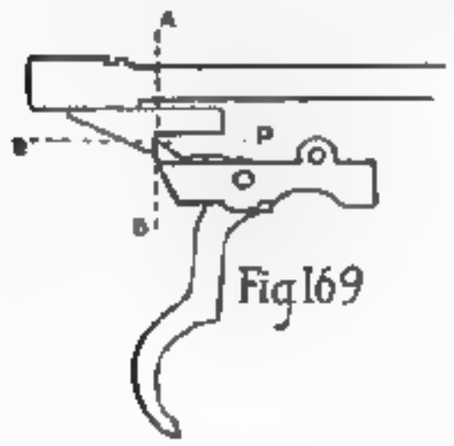

Fig 169

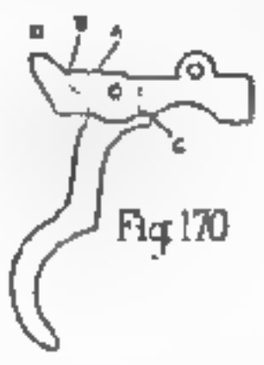

Fig 170

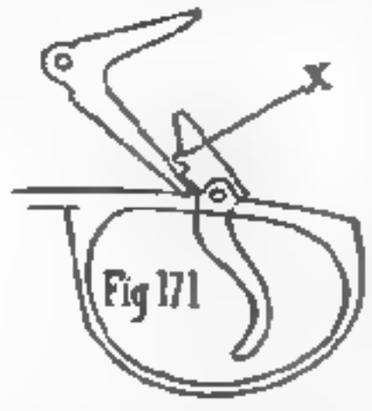

Fig 171

side of receiver and draws the sear downward. The position of fulcrum "a" near the trigger pivot provides considerable leverage, so that only about a pound pressure is required on this take-up, until fulcrum "b" strikes the bottom of receiver when fulcrum "a" becomes inoperative. This change in the position of the fulcrum increases the pressure necessary for the final pull, to release the cocking piece.

The first operation in reducing the trigger pull is to carefully polish the contact surfaces of sear point and cocking piece notch where they come together on line A—B in Figure 169. Get these as smooth as possible with the slip-bone, but do not change their angles nor round their faces. Leave them both square, sharp and flat. The upper point of the sear may be found somewhat rounded, and this should be brought to nearly a sharp edge by carefully polishing off the surface C—D in Figure 169, using a fine grained carborundum stone. Hold the sear flat and rub it on the stone, but take off no more metal than is absolutely necessary to sharpen the point, and do not bevel this surface. Finish by polishing with the hard Arkansas slip-bone. Now assemble and try the mechanism. You will probably find the trigger pull somewhat reduced, and much smoother in its action, but with considerable creep still remaining. Most gunsmiths remove this creep by grinding off more of the upper surface of sear on line C—D, Figure 169, and if you do it this way you must exercise extreme care lest the cocking piece be released before the

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take-up or preliminary pull is completed. I've seen the pull reduced in this manner on many a jack-leg job. A method which seems to me more sound is to carefully grind off a little of the upper surface of the fulcrum "b," Figure 170, which increases the length of preliminary pull before fulcrum "a" becomes operative, thus shortening the final pull. By this method the bearing surface between point and cocking piece notch is not in the least reduced, and if the two surfaces are properly polished the parts will slip back to their full position should the slack be taken up and the trigger then released. This is essential in any bolt action.

I use the above method on Springfields, Krags and Mausers, and it has always given first class results. By this means the final pull can be made anything from five or six pounds on down to a dirty look. It may be used also on the Lee-Enfield Action in which the same principle is applied in a slightly different manner as shown in Figure 171, the upper projection marked "X" being the one ground down.

When grinding down this part of a trigger, use very light contact with an emery wheel,—just one or two very light cuts. Then round off the corners and shape up with a carborundum stone (a file will not cut these parts), and assemble and try the mechanism. Take the metal down very slowly and try frequently. Should you be unfortunate, and take off too much, so that the gun fires before this part of trigger comes against the receiver, the mistake is easily corrected. Just grind a small amount off of fulcrum "a" (Figure 170), and be more careful thereafter.

TAKING OUT DOUBLE PULL. Some shooters, usually those who are shot-gun trained, or accustomed to shooting hammer rifles, never learn to like the double military pull and will have none of it. Theoretically this pull is necessary to complete safety. I believe this to be so, and practice what I preach on my own rifles. Yet in justice to the opposition I must confess I never heard of a Springfield cocking piece slipping past the sear while closing the bolt. If you want a quick, single pull, do your stuff on the trigger. Dr. Hudson used to employ a simple but very effective method, which consisted of fitting a strip of brass, or piece of hacksaw blade under the forward portion of the guard before placing it in the stock. The end of this piece was cut to a length to bear against the trigger, holding it back sufficiently to take out all the slack. If this is done the strip of metal should be drilled and attached to underside of guard with a screw, or it may slip and spoil the pull. At best it is a makeshift. Another way to use the same idea would be to fit the strip over rear of guard, with a hole through which the tang screw passed to hold it in place. A rectangular slot would be cut for the trigger to pass through, the front of this slot so located to hold trigger back the required distance. Another way is to solder a small piece of brass to the lower shoulder of trigger, at C, Figure 170, filing it down just enough to stop the forward motion of trigger.

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But a more workmanlike method is to alter both trigger and sear as shown in Figure 172. First grind out all of the fulcrum A, which lets the sear spring force the trigger back so that fulcrum B is in contact with receiver. This gets rid of the take up or preliminary pull immediately. Now we have a single pull, but a gosh-awfully long, draggy one, due to the contact between sear and cocking piece. We now grind off top of sear point, beveling it forward slightly as indicated by dotted lines at D, Figure 172. Work slowly

Fig.172

Fig.173

here, and try the parts frequently. Finally, when the pull has only a little drag, it is stoned out by polishing off both contact points on sear and cocking piece.

To further improve this type of pull, some gunsmiths have used the roller stunt shown in Figure 173. The end of trigger is annealed, and a slot milled in the end, into which is fitted a small hardened steel roller, on a hardened steel pin. The roller should turn freely without being tight. The sear point should not be ground off until the roller is fitted, as the roller has the same effect as building up trigger slightly, or of pulling down the sear.

The roller is really an unnecessary cinctum—more of a talking point than anything else. If the end of trigger where it bears against the receiver is polished smooth—and the receiver surface also—no roller is needed. Mighty few shooters ever look for trigger trouble on the bottom of receiver where the trigger bears. Sometimes a few strokes with a stone at this point will work wonders—and the shooter will wonder how on earth you ever did it!

SPEEDING UP LOCK TIME. Having adjusted the trigger pull to his satisfaction, the gunowner will next desire to regulate the action of the rifle for easiest operation and quickest possible lock time. If a bolt action arm, the polishing of the bolt and cocking cams as previously described is the first step. In other types of action, similar polishing and careful hand fitting to eliminate friction will make the action work much more smoothly and easily. Speeding up lock time is accomplished in a number of ways, depending upon

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the type of action, the underlying principle being that the stiffer the mainspring and the lighter the hammer or firing pin, the quicker the action, and vice versa. Naturally, also, the shorter the hammer fall or the stroke of the firing pin, the quicker the ignition.

Flat or V springs have much faster action than coil springs of piano wire; yet the latter have come into favor by reason of their great durability, and the fact that they seldom or never break, while the stiff flat spring is very easily broken. In a rifle action having

flat springs and outside hammer, the speeding up process should consist, first: of substituting a somewhat stiffer mainspring of the same type, carefully fitted and tempered; (See instructions for making, fitting and tempering springs, Chapter 24) second: of lightening the hammer; and, third: of shortening its travel from full-cock to firing pin. This last named step is practicable in some instances but not in others.

The usual plan for lightening a hammer is to drill holes in it in such a position as will not interfere with its strength or action—usually in the part that is concealed within the receiver. Sometimes the sides of hammer which project outside of the action may be undercut and several grains of metal removed. Every particle of weight that can be taken off will help; but good judgment is necessary in order not to weaken the hammer at a point of strain so that it will break from use. If the hammer is hard it must of course be annealed before it can be drilled or filed, and it should be carefully hardened again, and tempered, as described in Chapter 21.

The distance the hammer travels in its fall may be considerably shortened in many instances, by filing the sear notch to a higher position. This must be done slowly and carefully, with frequent firing tests to avoid the possibility of constant misfires. If the stiffer mainspring has already been fitted, and if the tension is adjustable, set it so that it is not quite on maximum tension, then shorten the hammer travel so that you get about one misfire every five shots. after which the spring tension is tightened up so she busts 'em every pop. If there is no mainspring tension screw, better shorten the hammer throw before changing the mainspring—then the heavier spring will eliminate the misfires.

Sometimes it is quite practicable to stiffen a weak flat spring by the addition of an extra leaf made of clock spring or thin spring steel, acting on the principle of the multiple leaf automobile spring.

On bolt action rifles the firing pin travel can be shortened slightly by grinding back the sear notch on cocking piece as far as its shape permits, and by slightly grinding the rear surface of the sear nose forward. Care must be exercised to maintain the original shape of these parts. On the Springfield this alteration can be used to shorten the firing pin travel from 1/16 to 3/32 inch. That isn't much—but as my friend Jack Little said when I asked him how he managed to support his nine kids—"Every Little helps."

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Cutting the "door knob" from the Springfield cocking piece will lighten it nearly an ounce, effecting a considerable saving in lock time. The headless cocking piece can now be obtained on special order from the Director of Civilian Marksmanship, but there's no need to spend the price of a new cocking-piece for this purpose alone. The cocking-piece is very hard, and must be annealed before it can be cut with saw or lathe tool. By working carefully with acetylene torch, and wrapping the portion which engages the sear with wet rags, it is possible to anneal the head without affecting the hardening elsewhere. Then the pin may be chucked and head cut off in the lathe, or it may be cut off with a hacksaw and afterward rounded slightly and smoothed up by filing or grinding. Re-hardening is not necessary provided the annealing was carried no further than the head. A somewhat safer method, if one is provided with a good grinder, is to cut off the head without annealing, using a very thin-edged carborundum wheel known as a "cut-off" or "parting" wheel. Wrap the cocking piece in wet rags during grinding so that the heat will not affect the temper, and dip it in water at frequent intervals.

Sometimes a new firing pin spring of the regular type will prove stiffer than the old one, greatly speeding lock time; or a spring may be wound of slightly larger piano wire, or in some instances one may use the same size wire and make the spring with a few more coils,—but not many, or it will not compress sufficiently to cock the firing pin. The special springs supplied by the Director of Civilian Marksmanship on the International Free Rifles were made of wire that is square or "keystone" shaped in cross section, and these springs are probably the best of all if they can be obtained.

One thing to watch in a target rifle where quickest possible lock time is sought, is the lubrication of the mechanism. Never use any but the lightest oil, as it is astonishing how much "drag" some good lubricating oils can put on a firing pin. Marble's Nitro Solvent Oil is the heaviest that should ever be used, and I doubt if anything heavier than watchmaker's fine oil is ever necessary inside a bolt. And if the parts are well fitted and polished as they should be, they should be wiped entirely dry before going into a match.

The 54 Winchester is worked down in much the same manner as the Springfield, as is also the Model '17 Enfield. The Remington Model 30, however, has not the double pull usual on bolt actions—a serious mistake, to my mind. Fortunately, however, for those who like this arm, the regular military pull may be supplied by purchasing from the Director of Civilian Marksmanship through the National Rifle Association, the trigger and sear for the Model 17 Enfield, and replacing the Remington parts with these; after which the pull may be worked down as desired.

The Russian rifle does not have a double trigger pull, and must be reduced by merely stoning the sear point and cocking piece notch. By working carefully, however, it is possible to develop a very good

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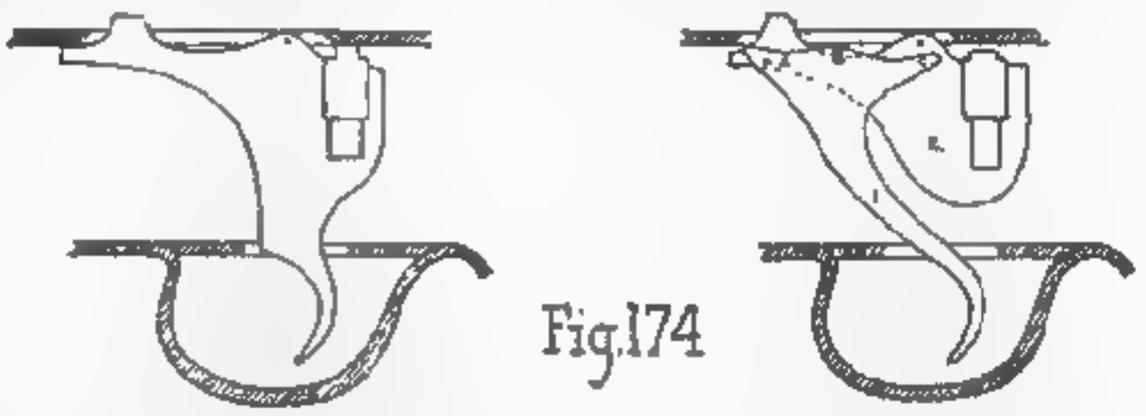
pull on this rifle, although it is not safe to work out all of the creep. The Model 5 Ross also has a single pull, which owing to the leverage employed may be worked down very satisfactorily without danger of jarring off as the bolt is closed. I believe it would be possible to make a new trigger to give the regular military double pull, but at this writing have not had time to try it. I have shot quite a



ORIGINAL TRIGGER — Fig.174 — IMPROVED TRIGGER

number of Ross rifles, some of them with pulls reduced pretty fine, and none have ever failed to stay cocked even when the bolt was worked very rapidly

Figure 174 shows an ingenious alteration made to the Model '19 N. R. A. Savage and described in the American Rifleman, to give it this same double pull. The original trigger was worked over as shown into a sear, and a new trigger made. This should prove a real improvement by permitting a much finer pull than is now possible on these arms.

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Chapter 29

SIGHTS AND TELESCOPES

THE simplest job of sight work, and the one most often desired by the gun owner, is that of exchanging the factory sights for others more to his liking, and as most factory sights are simply driven into the dovetail slots they are easily driven out again. The only danger lies in the possibility of springing or bending the barrel and this is easily avoided.

Suppose you have a '99 Model Savage rifle with front and rear sights dovetailed into the barrel. The front sight is a German silver "knife blade" type, the rear a buckhorn. Your choice let us say, is a Lyman gold bead front, a folding leaf sight on the barrel, and a Lyman No. 29 1/2 tang peep sight. You first of all secure the new sights, before touching those on the rifle. To assure getting the front sight the right height, however, it is a good plan to send the old one as a sample with your order. Before removing it from the slot, scratch a fine mark on surface of barrel, at a point as nearly as you can judge under the center of the old sight. Now wrap a thick piece of saddle skirting, or light sole leather around the barrel just back of front sight, and screw it snugly in vise so that only the part of barrel on which sight is fixed projects from the vise. All danger of injuring the barrel may be eliminated by assuring yourself that it is held rigidly. If held loosely, it may easily be sprung. Since only the muzzle of barrel is held, the butt of gun must be supported. Nail a piece of board temporarily on the bench, letting it project forward enough so that butt can rest on it. If the rifle is a take-down, it is not necessary to support breech of barrel—just be careful not to bump against it while in the vise.

BARREL AND TANG SIGHTS. All sights are driven into their slots from right to left—muzzle pointing from you—and driven out from left to right. Old sights may be driven out with

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a 1/4 inch brass or copper rod, but I have a liking for hard red fiber rods, as they cannot mar the sight in the least, while even brass or copper will leave a mark. A piece of 3/8 inch red fiber round rod will stand nearly as much hammering as the soft metals.

Tap lightly at first to "feel" of the sight—that is, to see how tight it is,—increasing the hammer blow just enough to start it about half way out, when it can be removed with the fingers. Too hard a blow will send it "kitin' " clear across the shop, to be lost, perhaps among the shavings—if you're that kind of housekeeper. Always save old sights and other parts and keep them in the odds-and-ends box. Never can tell when they'll come handy.

The rear barrel sight is driven out in the same manner—but be sure to grip the barrel in the vise as close to the sight as possible.

Before knocking out the rear sight, however, fit the new front sight. If it goes in too hard, note where edges of barrel dovetail bite into sight base, and file off base of sight slightly—don't file the barrel slot. If sight fits too loosely, use a thin brass or copper shim under it. If still too loose, peen over edges of barrel dovetail slightly, —and make up your mind to get a sight with a larger base at the earliest possible moment. Another good way is to tin under side of sight base with a layer of solder, then file solder smooth. This will usually give a good tight fit.

Dovetail sight bases as they come from the factory are often poorly shaped, the edges being rounded instead of beveled off sharp and straight. This fault is seldom found in Lyman sights, and not often in Marble's; it is most noticeable in the otherwise excellent Watson sights made by Belding and Mull. This seems a pity, too, since these sights have so much to recommend them.

When the base is not true and sharply beveled, be sure there is plenty of extra width before you start filing it—otherwise, when shaped to suit you, it may be loose in the slot. As soon as it will start in the slot, hold up to light and see if the angle of barrel slot corresponds with the bevel on sight base. Use a small, very sharp 3-square file for shaping sight bases, and preferably one having the teeth ground from one side, to avoid risk of cutting into the blade or rib of sight. A common 3-cornered saw file is useless for sight work—the edges are too thick, and besides very few sights have a 30 degree angle on the bevel. One of the handiest files for sights is a 6 inch mill file with one edge ground to the proper angle. Get this angle by the "cut and try" method, then keep this file to use for nothing but sight work. The smoothly ground edge is placed flat in bottom of slot—when cutting a barrel slot—or against the sight rib, while the teeth on sides are thus held at the correct angle with sight base or bottom of dovetail.

Drive in the new sight until its center almost—but not quite reaches the center mark previously made on barrel. Then fire a few shots to align, gradually driving sight to left until the shots are

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centered. Ten or fifteen yards is sufficient range for this. Were the sight driven clear to the center mark before testing, and you then found it necessary to drive it slightly to the right, the dovetail might be expanded sufficiently to make the sight loose

Now attach the tang sight by screwing it on, the screws fitting into holes already drilled in the tang, and filled with dummy screws at the factory. Turn in both screws loosely and tighten them together, a turn or two at a time. Look through the aperture, and see if it is in line with front and rear barrel sights—first making sure the windage is set at zero. If not in line, shim up one side of base with thin, hard paper until all three sights are lined up, and lower the elevation stem until, as you look through aperture you can see the front bead clearly centered in rear barrel sight notch. Then tighten screws, and again check alignment.

Now you can drive out the rear barrel sight and replace it with a slot blank, or a Lyman No. 6 folding leaf, or one of Marble's, King's, or Western's. The very best leaf is the Lyman No. 6 that is made for the 54 Winchester—it has two flat top leaves without any white triangles or other foolishness, and both leaves have a small U-notch. I hope I live to see the day when Lyman make all their No. 6's this way, instead of that infernal wide V-notch in the front leaf.

If the No. 6 as made for 54 Winchester happens to be the right height for your rifle, or if you can make it do by using a higher or lower front sight, you're not so bad off. Fold down both leaves, then sight in the rifle for the range to be used most with the aperture sight. I use a double newspaper page for sighting in, and find it makes the best target of all for adjusting sights. The printing on the page gives it a light gray tone at a little distance which shows up the sights more clearly than does a white target, and eliminates glare. The target I use is an inverted "T" the vertical bar running from the center of sheet to top edge, and the cross line running clear across the page. The lines are put on with black paint or ink. Aiming is done at the angle where the two lines meet. The new "minute of angle" target is also an excellent one for adjusting sights.

When sighting in, one may disregard elevation entirely until the shots are hitting somewhere along the center vertical line. Then set the sight stem up or down as needed until hitting the point of aim, if using a hunting rifle, or a sufficient distance above it to center in the bull, if a target arm.

Having the tang sight adjusted to your satisfaction, raise the lowest leaf of the folding barrel sight, and move sight in its slot until the notch is in line when looking through the peep. If the leaf is a bit too high, (let's hope it isn't too low!) fold it part way down so the bead will show when looking through peep. Then, when properly centered, the leaf may be removed from the base by taking out the small screws in either end, and filing it down the required amount—even cutting a new notch if necessary to file out

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the old one. Bevel edge of blade slightly forward and downward, and leave rear edge sharp. When cut to proper height, heat-blue it as described in Chapter 20.

If desired to have the second blade adjusted for a longer range—say 200 or 300 yards, first sight in the rifle to the required distance using the tang sight only—then line up the higher blade with this range just as you lined up the first one.

As soon as the tang sight is adjusted for your shortest range, carefully mark the elevation on the stem, and file down the small pin that comes with the sight, until, inserted in lower end of sight stem, it will just permit the stem to be set down to this range. This prevents the sight accidently being set too low for point blank range.

The foregoing instructions will apply to any sights set in dovetail slots cut in barrel, or in raised bases milled on the barrel; also to practically all tang sights, as most modern rifles have the tangs drilled for sights and the holes filled with dummy screws. Fortunately the leading sight makers have gotten together and agreed on the size base screws and distance apart on various rifles, so any standard make of sight may be used on any arm. The only variation of above will be found on certain Winchester rifles, on which it is necessary for the base of sight to extend over the tang screws. Lyman settles this matter very neatly in such cases by supplying a special tang screw with head fitting the countersink in their sight base, and screw long enough to reach through sight base and tangs of rifle. Thus the screw serves a two-fold purpose.

Some rifles, notably the Savage featherweights, have front sight bases milled integral with barrel, and instead of the dovetail, have a narrow slot milled lengthwise of the barrel, into which the new sight is inserted and held by a pin. To remove the old sight, hold barrel in vise as before described, and drive out the pin with a small drift punch. I find it advisable in such cases to throw away the pin, ream the hole slightly, and tap it for a 2/56 machine screw. Countersink the base a trifle on one side for the screw head. File down the head so it comes flush with base—deepening the slot if necessary—and cut off other end of screw flush. Thus an extra sight may be carried for emergencies, and easily changed in the woods with only a small screwdriver.

Front sights for Springfield rifles are attached in this manner, and it is a very good idea to replace the sight pin with a screw, as just described. In this instance, the sight is fitted into the movable stud which is separate from the barrel, and to avoid the possibility of injuring barrel, or of shearing off the screw which holds the movable stud in the fixed stud, it is best to remove the movable stud and hold it in vise while driving out the pin. Another mighty good plan is to get a new movable stud from the D. C. M. and use it in place of the old one. It will be noticed on most service rifles that the stud has been set off center to zero the rifle, and the stud

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screw hole, being to one side, makes it impossible to center the stud. By fitting a new stud it may be centered, and the hole drilled by inserting a drill through the screw hole in fixed stud. Thus a

smooth job is possible, without having the front sight perched off to one side like a stepchild, and the zeroing is taken care of on the rear sight.

Frequently one will desire a folding leaf sight on a barrel which is not slotted for a rear sight—and good gunsmithing practice advises against cutting such slots. A special band having a base for the folding leaf sight may easily be made as described in Chapter 24, which fills the bill quite completely.

Some shooters pooh-pooh the idea of a folding barrel sight. But I have seen many accidents happen to both tang and receiver sights out in the woods, and while often possible to repair them, it is then necessary to re-sight the rifle to tell where it is shooting. With a folding leaf on the barrel properly adjusted to the most commonly used range, the complete wrecking of the rear sight need not cause serious concern and the leaf would also prove valuable in re-setting the aperture sight after being repaired, without the necessity for sighting in.

RECEIVER SIGHTS. Many rifles, notably the bolt actions and some of the lever actions, are not well adapted to tang sights, and for these Lyman has provided excellent receiver sights, which are easily attached. A few other makers also produce a few receiver sights, but the Lyman line is best known, and are, I believe, the best all round sights in the world. Practically all receiver sights are alike in principle,—a solid steel block forming the base, being screwed permanently to receiver, and an elevation slide set into this base, with some means of raising and lowering it. An arm on upper end of elevation slide carries the aperture over the center of the action, and on some models both the elevation slide and the lateral position of the aperture are given positive control with micrometer screws. The screws are provided with a click, each click giving a change on the target of one minute of angle—or in some cases, of half minutes.

The most representative and perhaps the best known of all receiver sights is the Lyman No. 48, which is adapted to a great number of bolt action arms, but is best known for its almost universal use on the Springfield. A description of the method of attaching it to the Springfield receiver will answer for all others.

Since the Springfield receiver is hardened—the hardening extending clear through the metal in most instances—the first thing to do is to anneal the spots where the screw holes are to be drilled. There are two ways of doing this. The first, and best, is to first wrap the receiver in wet rags, leaving exposed only the lower part of ring on right side where sight is to be fitted. First, however, locate the position of screw holes roughly, with a light file scratch. Now lay a

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piece of sheet asbestos 1/8 inch thick, with a 1/4 inch hole punched in it over this mark, and heat through the hole to a dull red with an acetylene welding torch. Spot both holes in this manner, lay the asbestos over them, and let them cool. This anneals the spots without affecting the heat treatment of receiver.

An easier method, and one which Lyman recommends, is described in the circular packed with every Lyman 48 sight, and is briefly as follows: First mark the position of screw holes, and grind surface of receiver bright at these points. Then tin the spots heavily with melted solder. Then take a good big heavy soldering copper (weighing 2 pounds or more), heat it nearly red hot, (not recommended as improving the quality of the soldering copper,) and hold it over the spots of solder pressing it down firmly until the solder and copper are well cooled and solder begins to set. Now clean off the solder and the spots will be found soft enough to drill. Polish the spots with emery cloth, coat with copper sulphate, hold the sight base in correct position, and with a sharp awl or scriber mark the position of one of the holes. Drill this clear through, using the drill that came with the sight, then tap it out carefully, using short turns of the tap, and plenty of oil. Place the sight in position, and turn the screw in fairly snug. Then scribe the position of the other screw hole accurately through the screw hole in sight base; remove the base, carefully center punch, drill and tap this hole. In this manner the holes are made to register exactly with the holes in sight base, whereas if both holes were drilled before the sight base was fitted, they would probably be out of register.

Should this ever occur, the best way out is to set in one of the screws tight, then scribe the correction line through the other screw hole—this will be a mark just to one side of the hole in receiver. File the side of hole to this line, and also file out the side of hole in sight base to correspond. True up both holes with a small reamer and tap receiver hole for a larger screw. Such a botch need never occur, however, if the proper method is followed, and one screw set in before the position of the other is marked.

The same method of fitting will apply to practically any receiver sight on any rifle—except that on .22 caliber arms, and also some of larger caliber, the receiver is not hardened (more's the pity!). Always test the hardness of receiver with a small file mark before attempting to drill, otherwise a broken drill point will be the reward of your thoughtlessness.

For certain old models of lever action rifles, there are receiver sights made almost the full length of the receiver, the base pivoted at front end and swinging up at the rear for elevation. These and other models are always packed with a circular and necessary templets for drilling holes, and no other special instructions are necessary.

After the sight is fitted to receiver, the stock must be notched to accommodate sight base, and instructions for doing this will be

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found in Chapter 11. When all finishing has been done on the gun, and you are ready to put the sight on for keeps, heat the screws nearly red hot and turn them in firmly. In cooling they will shrink and hold the sight rigidly, with little possibility of ever working loose. The projecting ends of screws inside receiver must be filed off smoothly, or the bolt will refuse to enter. A 1/4 inch medium fine rattail file about 8 inches long is convenient for this purpose. After filing off screws, wrap a piece of emery paper around file and remove any burrs or roughness that remains.

When fitting a receiver sight, such as a Lyman No. 33, 34, or 48 to a Krag, note that the upper base screw hole is drilled at a slight angle downward. It is important to drill the hole in receiver at a similar angle, or the screw will not fit well. Most Krag receivers are merely case-hardened, so that spot annealing is seldom necessary—a few sharp blows with a hammer on a sharp center punch will break through the skin and give the drill a good start.

COCKING PIECE SIGHTS—Our next concern is the fitting of cocking piece sights—though why any man should want a cocking piece sight on a rifle is not clear to me. There never was a cocking piece that would go to the same position every time the bolt is closed, unless altered at the cost of several hours work. Moreover, the sight jumping away from the eye each time the gun is fired is not conducive to calling the shot, and always gives me a foolish feeling—like finding sand in oysters. But anyhow, here's the dope—use your judgment.

To fit a Lyman No. 1-A, or 103, to Springfield or Krag cocking piece, first dismount bolt and remove cocking piece. Wrap all but the knob with wet rags, and heat the knob red hot in an acetylene torch. The acetylene torch is recommended for all such work, as the heat from the small and very hot flame can be localized, while an ordinary gasoline blowtorch is pretty apt to draw the temper from the whole part before red heat is reached.

Now grind or file end of cocking piece head perfectly flat—or if you have a lathe, chuck it and face off the surface of head. Coat this surface with copper sulphate and reassemble bolt in rifle. With a small steel rule and scriber, mark a line across the face of knob through the exact center, and exactly horizontal. Dismount bolt, and hold cocking piece head up in the vise. Measure the narrowest part of sight dovetail, and lay it out on surface of knob, parallel with the center line. Make several shallow hacksaw cuts between the two lines, as close together as possible, then rough out the remaining metal with the edge of a coarse flat file. Now take a 3-square file, one side of which has the teeth ground off smooth, and with the smooth side resting on bottom of the shallow groove just made, undercut both sides slightly. Do not finish the cut with this file, as the angle is not quite correct. Grind off one edge of a small mill file until it has the same angle as the sight dovetail, and use this

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to finish the undercutting of the slot. A very fine-cut, die-sinker's knife blade file will be useful for finishing the slot. Try the sight often to be sure the base fits evenly, with the sight standing upright, not leaning to one side. If you have bad luck and get it crooked, pray that it leans to the left, and if anybody makes a nasty crack about it, tell 'em that's to allow for drift! If it leans to the right, don't show it around.

The above is the method available to most amateurs and small gunsmiths. With machine shop equipment available, however, it is an easy matter to set up the cocking piece accurately in a milling machine, and mill out the slot at just the correct angle.

When the slot is a good tight fit for the sight base, it is a good idea to case-harden the knob again, using the simple cyanide method described in Chapter 22. Keep the sear notch well wrapped in wet rags all the while, unless it was accidentally softened during the previous annealing—in which event case-harden the entire part.

There are several methods of taking out the side play in a cocking piece, so the sight will be more or less accurate. The simplest of all, if the receiver happens to be soft, is to peen the rear corners so that they bear firmly against the sleeve. I have done very well by this method on the Russian 7.62, on which a fixed peep sight was dovetailed into the cocking piece. Another method possible on some rifles is to mill a small slot about an inch long into the left side of sleeve, and fit into it a stiff spring which will bear against the side of receiver. The spring should be flushed at one end, and held with a small countersunk screw. Another way possible on rifles like the Krag, having rather thick receiver walls, is to drill a 5/32 inch hole into receiver wall at rear, into which is fitted a small plunger made of tool steel and hardened. The projecting end of plunger is rounded, and is held in firm contact with sleeve by a short coiled spring in bottom of hole. Various uses of plungers and methods of fitting them are described in Chapter 24.

Still another way of keeping the sight in line consists of beveling one side of the face of sear point, and beveling the sear notch on cocking piece to correspond. Usually the bevel comes on left side, and takes an angle of about 15 degrees. Theoretically, this causes the cocking piece to be forced firmly to right as the bolt is closed—and it may do so. But in my experience I haven't found that it improved the trigger pull any, nor does it prevent the sight being pushed out of line by dirt, piece of bark, sand, etc., which might get into the action. I can't feel right about a sight unless it is set up as tight as a native of Glasgow.

Figures 175A and 175B show two cocking piece sights for the Krag. "A" has no adjustment after it is fitted, being intended solely for hunting use, and to be sighted in with one load at one range. Elevation must be found by filing down a dummy front sight, as previously described. The dovetail base of the aperture is

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made extra long at both ends, so the aperture may be driven right or left as required, then the ends filed off even and the sight blued. The aperture was made by drilling in just the point of a 3/8 inch drill in the stock, which was afterward shaped up by filing. To attach, a hole is drilled in top of bolt sleeve, and tapped out for an 8/48 screw, the head of which is countersunk in the sight. The screw should be set in hot to assure a tight fit.

The drawing 175B shows a better sight made by Mr. John C. Harris, and described in the American Rifleman of May 15th, 1925. This sight has both elevation and windage; elevation being provided by the small tension screw set about the middle of the base, which is dressed thin at this point, and spring tempered. Windage is provided in the usual way with a transverse screw operating in a stud under the aperture dovetail, the screw being held at both ends against the base of sight. This sight would possibly be improved by having the aperture tapped for a small Lyman or Watson disk.

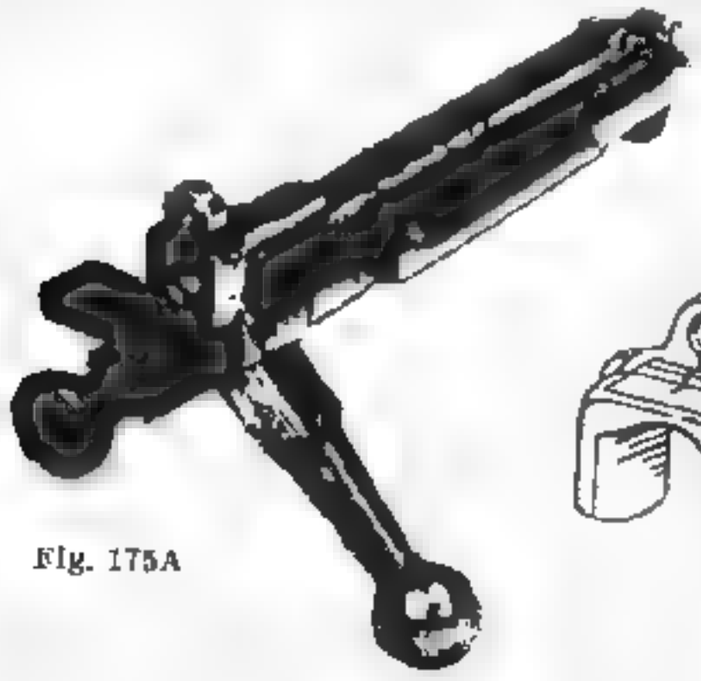

Fig. 175A

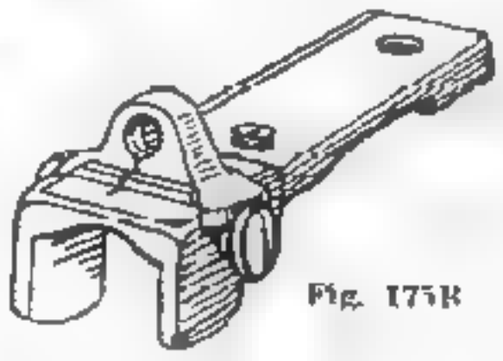

Fig. 175B

Cocking piece sights made for the Haenel-Mannlicher 9 mm., the Newton, Mannlicher-Schoennauer, and Mauser rifles are provided with a special nut for attaching to the cocking piece, and this nut has the sight base dovetail cut in it. It is necessary to drill and tap the cocking piece for the nut, for which purpose Lyman provides a special tap and drill, with full instructions.

When all is said and done, the best way to fit a cocking piece sight, is to send the cocking piece to Lyman and let them do it for you. There is but one better way—use some other kind of sight.

BOLT SLEEVE SIGHTS. There are several recent developments in bolt sleeve rear sights, and this type bids fair to become increasingly popular One of the best designed, and poorest made is the Howe-Whelen, shown in Figure 103. (Chapter 14.) The elevation slide and windage arm are almost identical with the Lyman

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48, and the same adjustments are used. The base of sight is milled from a block of steel which has the same inside cuts as the bolt sleeve, which it replaces. To fit this sight it is only necessary to dismount the bolt, and discard the sleeve; then reassemble, using the sight base as a sleeve—it interchanges perfectly. The only fitting required (and it is seldom needed) is a bit of stoning on the point of the sleeve latch, to make it fit easily into the small recess in end of bolt.

Whelen and Howe did a mighty good job when they worked out this sight—a much better job than the manufacturer did when it was put into production. For, due either to soft, un-hardened material, and partly, I think, due to the elevation slide being much narrower than that on the Lyman 48, the slide quickly worked loose in the base, and could not be tightened enough to prevent its wobbling. For this reason alone I discontinued using the Howe-Whelen sight, much as I liked it otherwise.

The new Belding & Mull Bolt Sleeve sight has much to recommend it, particularly for use on a hunting rifle. See Figure 176A. This sight is "bull strong," being well bolted through holes drilled in the bolt sleeve. There are two flat springs on the base, or rather one spring with two lips, which ride on top of the tang on either side, bringing the sight positively to position when bolt is closed. Being attached to the sleeve and not the cocking piece, the sight is stationary and does not move when the rifle is fired. The principal objection to the B. & M. sight for target use is the method of adjustment. The screws have small heads with wide coin slots, which does not facilitate quick adjustment, and the clicks apparently do not have a definite value on the target like the Lyman 48 and the Howe-Whelen. There are in addition lock screws for both windage and elevation, which makes this a good hunting sight for use with one load, and with adjustment for one range. It looks somewhat clumsy, however, due to overhanging the forward portion of the grip.

The Belding & Mull sight is not adapted to ready attachment in the home workshop, but the makers fit it without additional charge—only the firing pin and striker assembly and bolt sleeve are needed.

Figure 176B shows the latest design for a strictly hunting rear sight—to my mind the most practical, most substantial and best appearing sight ever made for any rifle. It was designed by Mr. Elmer Stahl, of the Niedner Rifle Corporation. The sight itself is built into a special base which takes the place of the regular bolt sleeve. Both elevation and windage are adjustable by means of screwdriver head screws, and both adjustments can be rigidly locked—so firm, apparently, that nothing less than a sledgehammer would alter the adjustment or damage the sight.

The sleeve portion of this sight has no safety lock—this part being eliminated to permit of mounting a scope very low on the rifle

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if desired. Heretofore, scope mounts were made high enough to clear the safety lock when turned up, which made the scope sight line higher than would have been necessary otherwise. Mr. Stahl's cleverly designed sleeve eliminates this objection to a low set scope, giving riflemen just what they have been asking for, these many years.

To provide for locking the action when rifle is cocked, a safety lock is built into the forward portion of the trigger guard, similar to the safety used on some Remington rifles. This not only locks the firing pin and sear, but also locks down the bolt—a most valuable feature hitherto lacking on the Springfield, and appreciated by the hunter who has had his bolt pulled open when going through brush. This same bolt locking feature is found also on the Howe-

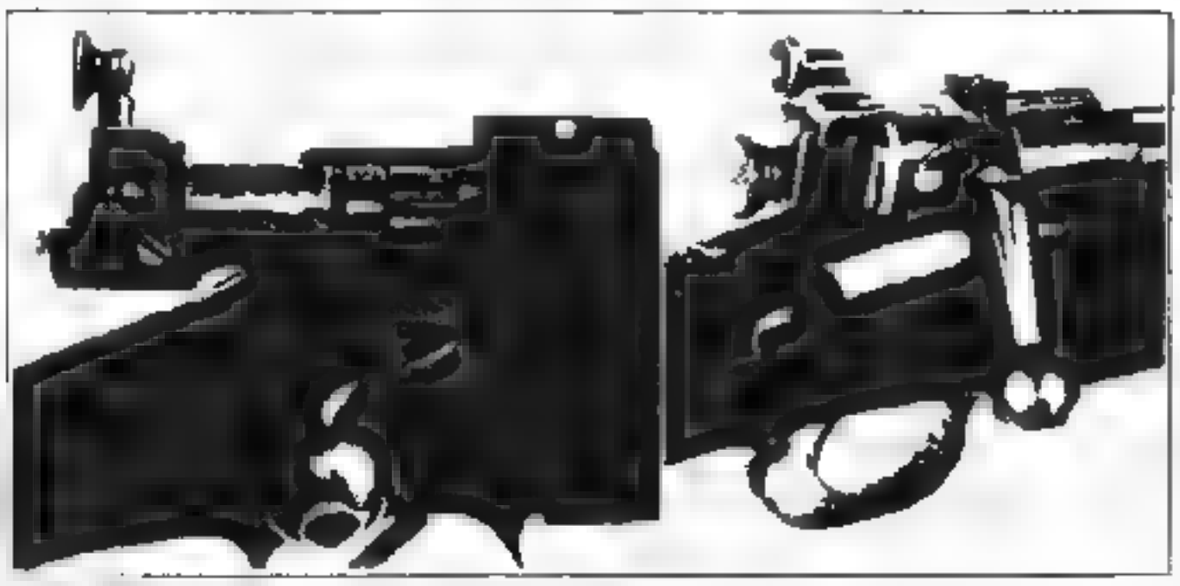

Fig. 176A Fig. 176B

When, but as that sight is really better for target use than for hunting, locking the bolt is less essential.

Now comes the fly in the ointment. This really splendid Stahl Sleeve Sight and Bolt Locking Safety combination costs only $50.00 installed, at the present writing. Which means that yours truly, and a lot of others afflicted with beer incomes and champagne appetites in the matter of guns, will have to possess our souls in patience for the immediate present, or until this equipment is in regular production. At this time it is made and fitted to order only, it being necessary to send Mr. Stahl the entire rifle to be fitted.

FITTING FRONT SIGHT BASES. When a barrel has been cut off to shorten it, or to remove a damaged muzzle, as described in Chapter 24, it is necessary to make provision for a new front sight. Usually the better plan is to provide some kind of base, such as the Springfield fixed stud, which is about 5/8 inch inside diameter, hence readily adapted to a number of sporting size barrels.

When the barrel has been cut to the required length the fixed stud is started on the barrel and peened to a snug fit. It is usually best

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to fit the stud to barrel before cutting barrel to length. Slip it on as far as it will go, give it a tap or two with a piece of brass, then tap smartly all over the barrel band with the ball end of a light hammer. This stretches the band so it can be driven on a little further. Continue the peening and driving on until the sight is in its final position, then cut off and crown the barrel.

The band of this fixed stud may be sweated or pinned to the barrel, or both. First place the barrel and action in stock, and tap the sight base right or left as required to line it up vertically. (See detailed instructions for fitting sight ramps in Chapter 24.) Tin barrel and inside of band as described for ramps, and sweat band in place. Take a small "mouse-tail" file and insert it through hole near rear end of fixed stud. File barrel surface inside this hole, then insert a drill a trifle larger than the hole and drill it out smooth, then drive in a pin made of a piece of drill rod one size larger than the drill you used, and the job is ready to be cleaned up and polished for bluing. If desired to merely heat blue the sight and muzzle of barrel, do not sweat the band on—merely pin it. The best job is done with both pin and solder, then the barrel and action should be completely reblued.

The parts usually required for fitting a Springfield sight base and the price are:

1 stud, fixed	.27
1 stud, movable, assembly	.35
1 pin, front sight	.01
1 sight, front	.02

These may be purchased from the Director of Civilian Marksmanship by any member of the National Rifle Association. Send 5 cents extra to cover postage.

After the fixed stud is attached, fit the movable stud in place, insert the sight blade and pin. Now set the rear sight at the lowest possible position, and sight in the rifle for the desired range. Probably it will shoot low, so file down the front sight blade gradually until you have the required elevation. If the rifle shoots too high, file a higher sight blade out of a piece of sheet iron or brass, then dress it to correct height when sighting in. This filed sight may now be sent to Lyman, Marble, or King as a pattern, and a new gold or ivory bead sight the same height will be supplied. These companies make sights for the Springfield in several different heights, and will also make up any special heights required at a small additional cost.

A very attractive and practical front sight is the Western Full Block sights made in Denver. This has the movable stud and sight blade with bead, all made in one piece, and is furnished in several heights at $1.50. Sight in your rifle with the regular Springfield assembly, then remove the movable stud with sight blade attached, and send it in when ordering the full block sight.

RAMP FRONT SIGHT. The ramp, or inclined plane lead-

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ing up to the front sight is steadily becoming more popular on American arms, although the idea was originated in Europe. At least one manufacturer in this country is furnishing some of their rifles with a small neat ramp into which the front sight is fitted, as standard equipment. The ramp not only gives a pleasing appearance to rifles requiring a high front sight, but it also provides a dull matted surface in front of the sight which reflects no light, and to a large degree removes the disturbing influence of heat waves from the barrel.

The manufacture of sight ramps is fully covered in Chapter 24, while the method of attaching them by sweating or brazing, will be found in Chapter 23. Our principal concern in this chapter is the fitting of the sight itself to the ramp. The easiest method is to cut a cross dovetail in the top of ramp, and fit in any of the standard dovetail base front sights. Due to the fact that the ramp is narrow, usually 1/4 or 5/16 inch, the sights having short bases should be selected, so that the ends may not project too far over the edge of ramp. The sights made for the 52 Winchester, the Newton, the Mauser, Mannlicher-Schoennauer, etc., all have such bases. Or, any sight you select will be supplied with short base by the makers on request.

To ascertain the correct height of the sight when attached, first solder a piece of soft metal—brass, copper, or zinc—to the flat top of the ramp after it is attached. Dress this up with a file to form a sight blade, at least 1/8 inch higher than you think it should be. Set the rear sight as low as possible, and shoot the rifle on the range, filing down the temporary sight blade until you have the required elevation. Lateral adjustment may be disregarded, provided the rear sight has windage adjustment.

Now measure with calipers the over-all distance from the top of sight blade to bottom surface of band. Figure 177A. Better yet, measure this with a micrometer if you have one large enough. From this subtract the over-all dimension of your front sight, from top of bead to bottom surface of base. Set the hermaphrodite calipers for this new measurement, and scribe it on front end of ramp. Figure 177B. Now project this mark around both sides of ramp, the marks on each side representing the depth of the dovetail cut. Measure the thickness of the dovetail base of your sight. Scribe a line above the first one made on sides of ramp, this distance from it. This gives the top surface of ramp. Figure 177C. Now file or grind off the temporary sight blade and dress down top of ramp to the last line marked on the side. Between this surface and the remaining line, lay out the shape of the dovetail slot, measuring and cutting the dovetail in the manner described for fitting a cocking piece sight. Be sure to use a square across top of ramp to keep the sight dovetail square with bore. When fitted, the top of sight bead will be very nearly the same height as the temporary sight blade was.

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There will of course be a few thousandths inaccuracy, which may be taken up with the rear sight adjustment, and this inaccuracy in fitting will amount to no more than the variation between different lots of ammunition.

After the sight is in place the sloping surface of ramp should be filed down to final shape and the surface matted. (See Chapter 19.)

Caterpillar type front sights are made in both Lyman, Marble and Sheard, and are very desirable on a ramp, but more expensive to fit. They are supplied in heights varying by .010 inch, which makes it easy to secure the correct elevation. The approximate height should be first determined by sighting in with a dummy sight as just described, then select the height of caterpillar desired, and mark the depth of the dovetail on front end of ramp. The barrel is now clamped to the bed of a milling machine on V-blocks set on base, with the ramp vertical. A milling cutter must be made to cut a dovetail slot same width or slightly narrower than the base of sight.

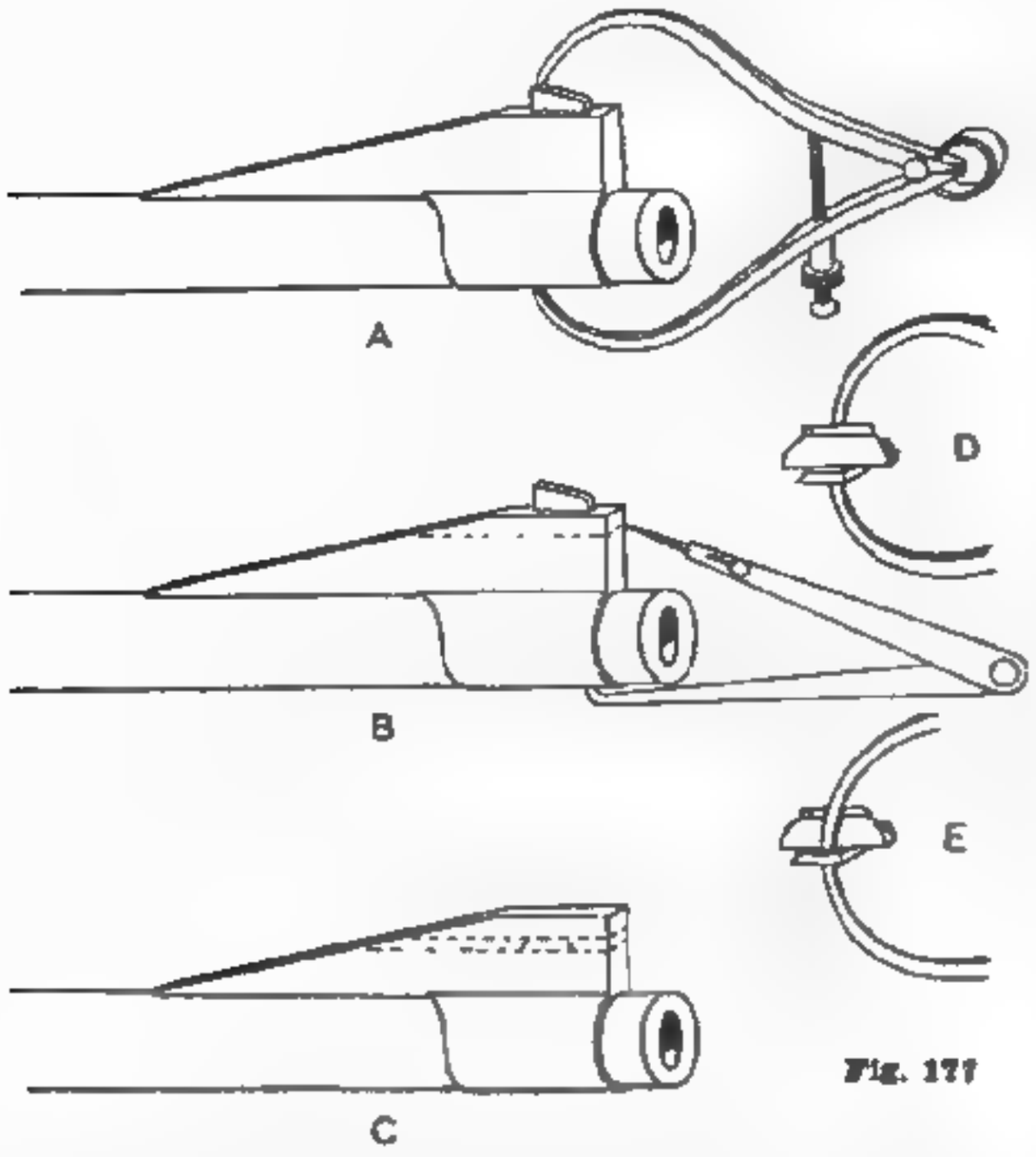

Fig. 177

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The ramp is fed against the edges of revolving cutter until the dovetail is the required length—usually somewhat shorter than the base of sight, which is made extra long, to be cut off flush after it is fitted. This is a job to be attempted only by an expert machinist or toolmaker with good equipment. The gun owner, or the shop that is called only occasionally to turn out a ramp job, will find it convenient to send the barrel with ramp fitted in the rough, and dummy sight filed down to the correct height, to the Marble Arms & Equipment Company, Gladstone, Michigan, and let them cut the slot and fit the proper height of sight.

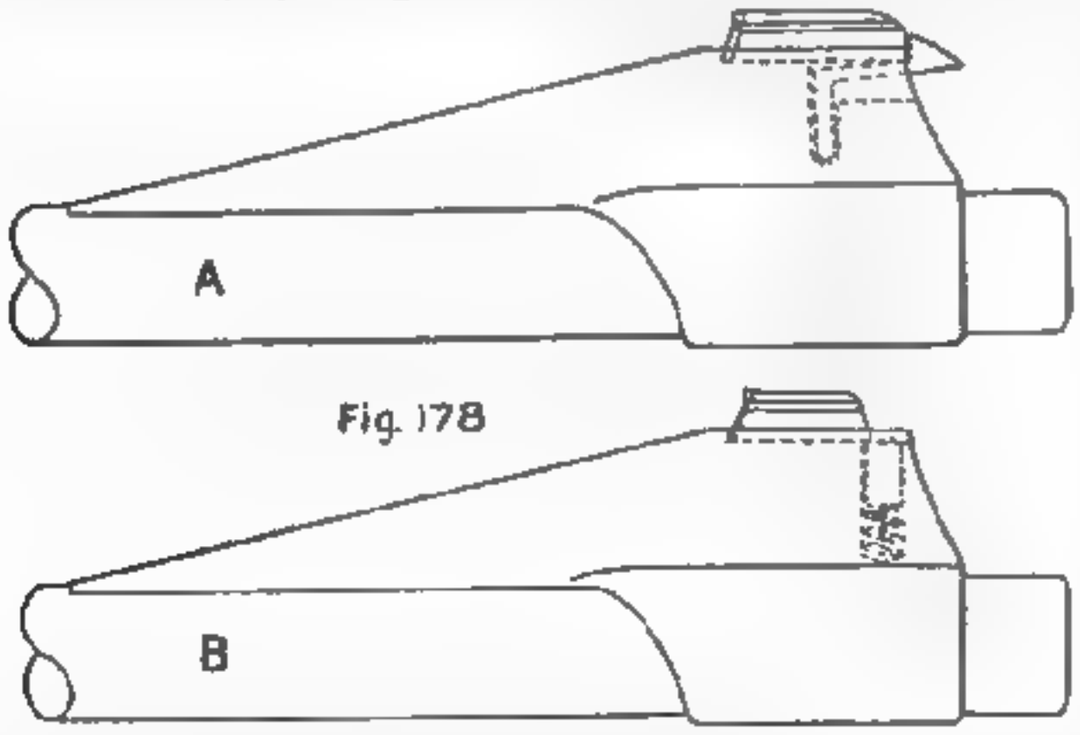

Fig. 178

The caterpillar sight may be a sung driving fit in the slot, with no other means of holding it in place. Or it may be dressed off on the base to an easy sliding fit, and held in position by either of the methods illustrated in Figure 178. The drawings are self explanatory, and a good mechanic can make either of the catches without difficulty. The plunger catch at "B" is the easiest, and in my opinion the best. It requires no extra milling operation like the catch at "A," all that is necessary being merely to drill the hole for plunger and fit it in place, on the coil spring, then slide the sight in over it. The plunger should be turned from 5/32 inch drill rod.

The Watson No. 2 and No. 8 sights are very desirable for mounting on a ramp. They should be ordered with the lowest bases obtainable, and after fitting the projecting ends of dovetail may be dressed off flush with sides of ramp. The No. 2 Watson is a combination target and hunting sight, with interchangeable discs or reticules giving the shooter his choice of several beads mounted on either a post or a thin horizontal wire, or aperture disc or flat top post for target work. Some shooters find a sight enclosed in a hood too slow for hunting, and for them the beads without hood will give better results. It is not the purpose of this chapter to tell a man what sights to use, or why, but merely to tell him how to fit the sight he prefers.

SLOTTING BARRELS. When a quick and simple job is desired, it may be considered unnecessary to go to the trouble of making and fitting a ramp or other front sight base, but merely to dovetail one of the standard sights into the barrel. The method of cutting the dovetail has already been described. Round barrels present some difficulty in getting the dovetail cut square across and to the proper depth on each side. One way to do this is to set the muzzle of barrel in a vise with just enough of upper barrel surface

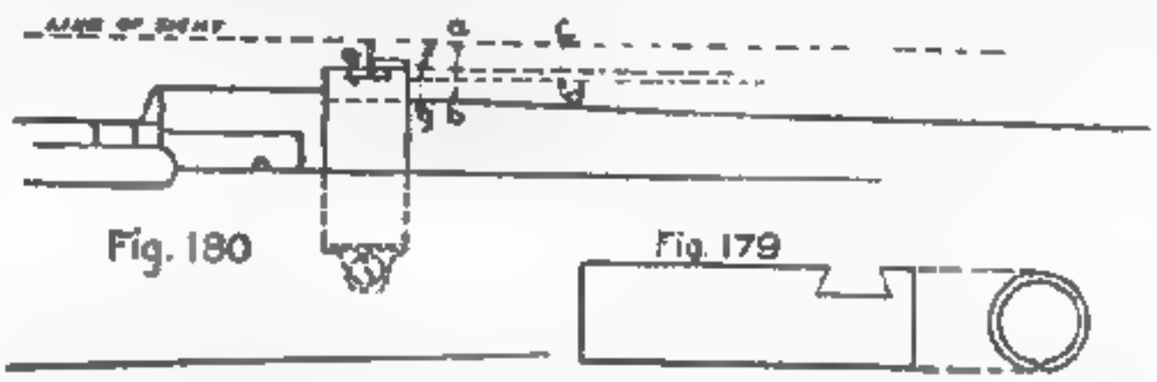

Fig. 180

Fig. 179

projecting above the jaws so that the jaws will regulate the depth of the cut. The barrel should be turned until the rear sight is level before tightening the vise.

If a number of barrels the same size are to be slotted, it will pay to make the simple filing jig shown in Figure 179. This is merely a piece of Shelby tubing 2 inches long to slip snugly on barrel, with a straight sided slot the width of upper portion of sight dovetail cut in one side, and the lower side split with a hacksaw cut. This sleeve should be well case-hardened to make it file proof. Slip it in place on the barrel with the slot in tube over the spot where barrel slot is to be cut, and tighten up the vise jaws on this sleeve. Then file barrel through the slot in sleeve until the file touches both edges of sleeve. Slip it off the barrel and undercut the dovetail.

LAYING-OUT SIGHTS AND BASES. In Chapter 24 we have described barrel bands with a dovetail sight base on their upper surface, to take the Lyman No. 6 or other folding leaf sight. Figure 180 illustrates the method of determining the proper height for this sight base when fitting the sight. The illustration shows a band fitted to breech of a Springfield barrel, but the general instructions might be applied to any other.

It is assumed that both the front sight and the rear aperture have first been fitted and sighted in. Set the rifle in vise and stretch a stout thread from top of front sight through center of aperture; measure distance from thread to top surface of barrel (at the point where band is to be placed) with sharp pointed dividers or inside

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calipers. Now measure the distance between divider points with micrometer, or if you have no mike, use a scale, getting the distance in 64ths at least. Now measure height over-all of your leaf sight, from top edge of lowest leaf, to underside of base. Next measure thickness of the dovetail base, and subtract this measurement from the over-all measurement of sight. Subtract the result from the first measurement (distance from line of sight to surface of barrel) and the resulting figure gives you the required thickness of the sight base portion of your band, or rather the distance from its inside to outside surface at center—f-g, Figure 180.

Example, (referring to Figure 180) a-b is the distance from line of sight to top of barrel, and measures .524 inch; over-all height of Lyman No. 6 leaf sight with lower leaf raised, is .395 inch—c-d; base of this sight, e, is .102 inch thick; .395 inch—.102 inch=.293 inch, which is the height of the Lyman No. 6 not including the base. .524 inch—.293 inch=.231 inch, which is the thickness required for sight base portion of band,—f-g.

Set a pair of sharp dividers as nearly as possible to this figure by using the mike, and mark off the distance on band; file down the required amount and cut the dovetail slot. The inaccuracy resulting from this method will be slight, and can be corrected by slightly

filing down the sight leaves slightly after fitting, if you took the precaution of leaving the base slightly thicker than required. If you cut the base down too much, it's just "too bad."

When the open rear sight is removed from a barrel slot and it is not desired to use a folding leaf, the slot can be filled with a blank obtained from the sight manufacturer for this purpose. Western Gunsight Company have the most attractive blanks, made in an ornamental shape with a mountain-sheep head engraved. If the barrel is to be reblued the slot may be blanked out and ends of blank dressed off even with the barrel, making the slot invisible after bluing.

SIGHT SCREWS: Occasionally we hear complaints that the screws in the sight base "worked loose and allowed the sight to slip out of place, causing me to miss the only buck I saw on the whole trip." The sight manufacturer, of course, gets the blame. Investigation usually discloses that one of the original screws has been lost, and replaced by a standard machine screw; or, that the enterprising gunsmith who fitted the sight, didn't have the correct tap as furnished by the sight maker, and used the nearest thing to it he could find. Consequently the screw either did not fit the thread, or else too coarse a thread was used—for neither of which the sight manufacturer was responsible.

The screws used for attaching tang and receiver sights have finer threads—usually 40 to 48 threads per inch—than standard machine screws. The narrow-gauge mind instantly jumps to the conclusion that the maker has chosen a "bastard" thread in order to force the

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owner to buy the screws from him. Wrong! The maker knows from experience that the vibration of a rifle—even a .22—quickly tends to loosen any screw, and the coarser the thread, the more quickly it is loosened. Consequently he supplies fine thread screws with his sights, to overcome this tendency. He does not expect to sell you more screws—and unless you are clumsy enough to lose the ones that come with the sight, you won't need any more. If you do, they cost you a trifle—perhaps from one to five cents, according to size. The special taps for these screws cost but little more than the regular commercial sizes, and there is absolutely no excuse for any gunsmith using "off" sizes. Use the screws the manufacturer recommends, tap the holes with the taps he supplies, set the screws in tight as previously explained, and your sights will not be continually dropping off and rolling down the hillside. The following tables give the screw and thread sizes for most standard American made tang and receiver sights, also barrel sights when attached with screws:

TAPS AND DRILLS USED FOR MOUNTING LYMAN REAR SIGHTS

No.		Inches	Tap Drill No.	No.		Inches	Tap Drill No.
16	Russian 7/62	.140	43	41	Win. 95	.6235	56 47
21		.3/16	34	42		.37	40 36
23		.140	43	43	Stev. O.H. Pistol	.137	40 36
24		.140	43	44	Stev. O.H. Pistol	.137	40 36
25		None				.137	40 36
26	Mannlcher	None		45		.0935	56 47
28		.3/16	36 19	48		.140	43 31
40	Sav 40 & 45	.137	40 36	50		.135	43 36
41	Win. 95	.140	43 31	53	Win. Musket	.140	43 31
41	Mar 93	.140	43 31	54		.140	43 31
41	Mar 95	.140	43 31	1*A	Mauser Nut	.0935	56 47
41	Win. 07	.125	43 36	1*A	Mann Nut	.0935	56 47
41	Win. 10	.125	43 36	1*A	Russian Nut	.0935	56 47
41	Rem. Auto	.125	43 36	1*A	Marlin 28	.3/16	36 19

On all other combination rear sights necessitating new mounting screw holes the Stevens tap .127-in.—40 is used. No. 36 Drill.

TAPS AND DRILLS USED FOR MOUNTING MARBLE REAR SIGHTS

	Thread Size
Winchester	
Short	.185—32½
Long	203—32
Receiver	.140—43
Marlin	
Short	166—40
Long	316—36
Remington	
Short	.175—32
Long	.196—28
Model 8	.152—40
[redacted] & 14	.140—44
Savage	
Short	.166—40
Receiver Sight	.156—32
NRA Leaf	.187—36
Stevens	
Short	.125—40
Colts	
Short	.187—26
Long	.218—24

FITTING TELESCOPE MOUNTS AND BASE BLOCKS.

The job most often desired by the amateur will probably be the fitting to the barrel of dovetail blocks for the mounts of Winchester, Fecker, or similar target scopes. This is not a particularly difficult job, especially since most target barrels are heavy, hence there is little danger of drilling through into the bore.

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Assuming that the rifle has iron sights correctly aligned, take a long thin steel straightedge, and after chalking the approximate location of the blocks on barrel, hold one end of straightedge even with the center of front sight, the other on center of rear sight, and scribe the center line lightly on barrel where blocks will go.

A pair of hardened V-blocks with clamps and a sheet of heavy plate glass about 6 by 18 inches are needed. Rest the glass on a smooth level table or bench, and the V-blocks on the glass, and rest the barrel in the V-blocks, as in Figure 181. Now find some flat surface—usually on the receiver, and turn the barrel until this sur-

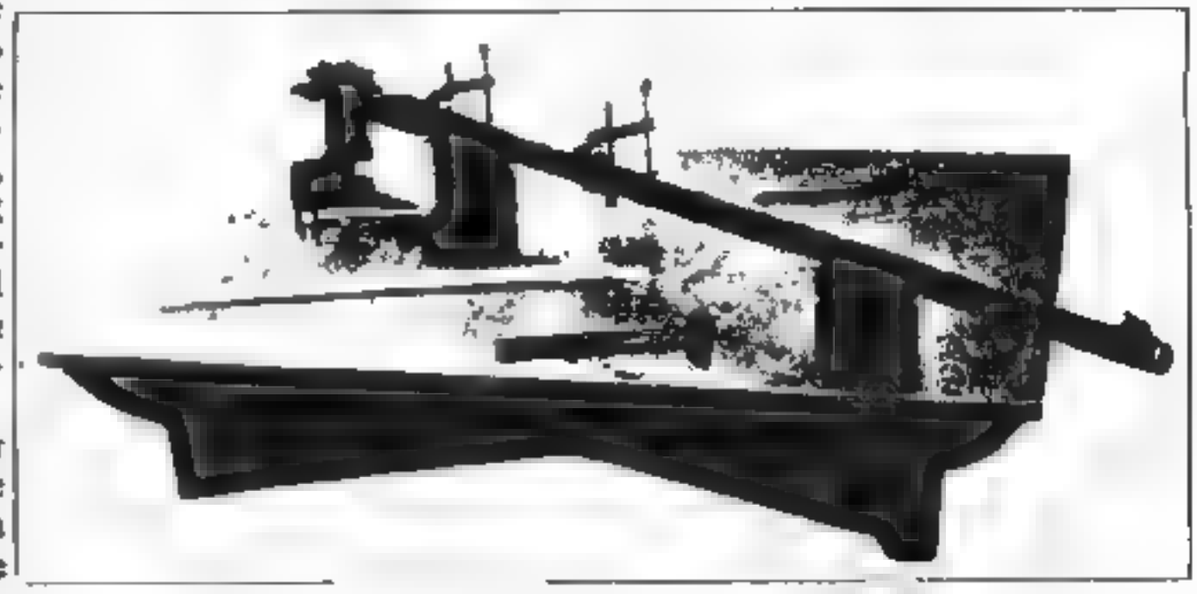

Fig. 181

face is either parallel or at right angles to the surface of the glass. Two small try-squares should be used, one on the surface of receiver, and the other on the glass. When the barrel and receiver are as nearly vertical as you can get them, tighten the clamp on one of the V-blocks to keep it from slipping.

Now place one of the scope blocks in position on barrel and fasten it with a small hand clamp (parallel clamps are better than C-clamps for this job). Place the head of a try-square on surface of scope block, and another square on the glass surface plate, with blades touching, as in Figure 182B. Loosen the hand clamp and move the block on barrel until the two blades are exactly parallel. Now change the two squares to the position shown in Figure 182A, and with inside calipers measure distance from edges of scope block to blades of squares. When the block is centered as truly as you can get it, set the clamp up tight, re-check the alignment and scribe the position of one screw hole. Drill this hole very carefully with a new sharp drill, measuring its depth frequently. If the barrel is thick you need not worry about getting the hole too deep. On a very thin barrel it is best to drill the hole to about 1/32 inch less than its final depth, and "bottom" it out square with an end-mill the same size as drill.

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If an end mill of the proper size is not available for bottoming out the hole, make a flat drill of the proper size. This is made by taking a piece of drill rod same size as drill used, and filing both sides flat. Grind end square, and file a very slight relief on point.

If you ever go too far and drill into the bore, don't try to say anything,—words are weak and futile. Just toss the whole works out in the alley and go jump in the nearest deep body of water. An anvil or two hung on the neck will assure best results.

Another thing to avoid, after the hole is drilled and tapped in the barrel, is forcing the screw through the thin metal at the bottom

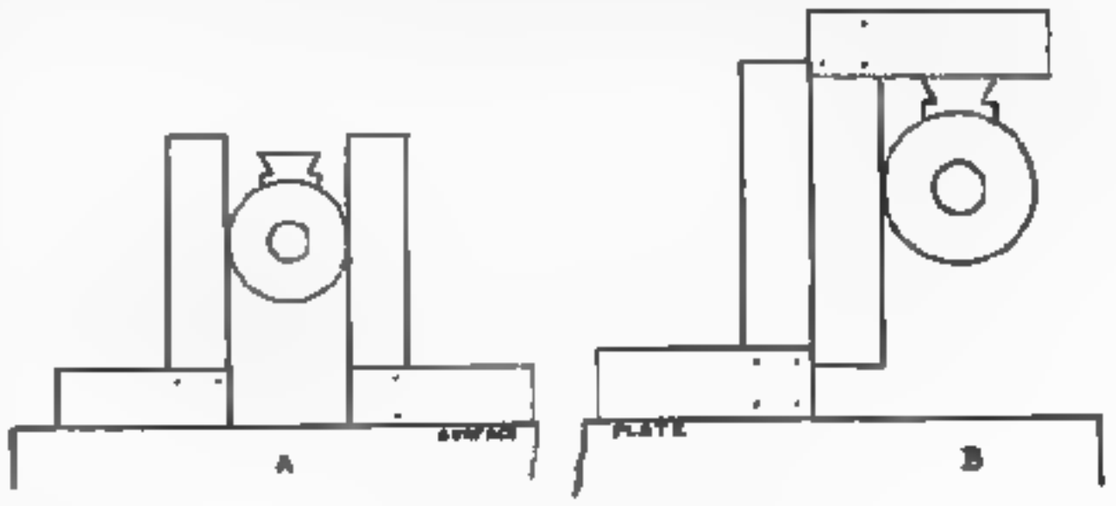

Fig. 182

and into the bore. While this is not a common accident, it has nevertheless occurred in shops which should have known better. When trying the screw in the scope block, note whether it begins to tighten up before the head is down tight in the countersink. If so, withdraw screw and carefully grind off a little from the point. To get the full holding power of the screw the end should not touch the bottom of the hole.

After the hole is drilled comes the tapping. *Now be careful!* The tap is tapered at the point for relief, and it will do no more than start the thread in such a shallow hole. You should have three taps,—starting, middling, and bottoming. Use the regular tap as it comes for starting. Grind off the point of another until it has a very little taper—this is the middling tap. The bottoming tap has every bit of taper ground off.

Do not try to force the tap. Begin with the starting tap, turning it forward about 1/8 turn, then backing it up and advancing a trifle with each movement. Be satisfied with one or two clean threads from this tap. Then take the middling tap and work the thread deeper, till point of tap is felt to touch bottom of hole. Next turn in the bottoming tap, cutting the thread clear to the bottom. If there's the slightest doubt as to whether the tap has really struck bottom or is merely turning hard, take it out and inspect carefully. Breaking off a tap in the hole is not conducive to one's hope of a

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hereafter If this should happen, sometimes the tap can be worked out by light blows on its edges with a small prick punch, but usually it is necessary to leave it in the hole, grind off any projecting point, and drill another hole a quarter of an inch away.

Having successfully tapped out the hole with no accident, set the block in place and turn in the screw. Now mark the position of the second screw hole, remove block, drill and tap hole. Set block in place again with screws in snug, and scribe line all around block on barrel. Remove block and file or scrape under surface bright, and tin with very soft solder. Scrape bright the spot within the outline of block on barrel, keeping about 1/16 inch away from the line all round. Cut a hole in a piece of thin leather, the same shape as the outline of block; place this on barrel, and tin the spot through the hole. Get as thin a coating of solder as possible on the barrel—if it piles up, scrape it down when cool. Place the block in position, heat the screws to a dull red and turn them in fairly tight. Heat block over gas flame until the solder just melts and shows at edges. The solder will not stick here because of the bluing, and the finish will not be harmed. The hot screws will shrink in cooling, making the union of block and barrel as solid as if they were one piece.

The second block is attached in exactly the same manner, with care to see that it is properly lined up with the other, and their top surfaces parallel.

Seven and two-tenths (7.2) inches between centers is the best distance to space the scope blocks on most rifles, this distance giving true half-minute of angle values on the mount adjusting screws.

Some of the special mounts supplied by Belding & Mull require very careful fitting of the bases, and such work should always be sent to the factory. Then, if the job should not prove satisfactory, the makers alone must take the blame. Better to be safe than sorry.

FITTING RECEIVER SIDE MOUNTS. There is a new type of hunting scope that has become quite popular the last year or so, which is attached to the receiver of the rifle by a mount which dovetails onto a base plate set on side of receiver. The most popular scopes of this type are the Zeiss Zeilklein, Helsoldt Dialyt and Zeilklein, and the Noske. The only mounts worthy of consideration for bolt action rifles for use with these scopes are those made by Noske and by Griffin and Howe. The Noske mount is the older, and perhaps a bit stronger of the two—also the more clumsy. In principle the two are somewhat similar. The G. & H. mount has one advantage—the bands which encircle the barrel of scope are split, with a screw on each side, so that the bands may be entirely separated and the scope set in the mount without dismounting any part of the instrument. While with the Noske, it is necessary to dismount and remove the elevating disc and other parts attached to the outside of the instrument. However, this is quite simple, and no damage will result if you handle your screwdriver with care.

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Instructions for dismounting the elevating mechanism of both the Zeiss and Helsoldt scopes is given further on, and no further dismounting is necessary, nor should any be attempted. If the scopes for any reason need repairs, they should always be sent to the makers.

Having the scope set into the desired position in the mount, we are ready to fit the base plate onto the receiver of rifle. A description of the method of fitting the G. & H. mount to a Springfield will answer for all others.

The mount comes completely blued with the exception of the base plate, which is merely polished. On the side of this plate five holes are marked and centered, but not drilled. The first, third and fifth are screw holes, the second and fourth are for taper pins which help to take up the jar and prevent the screws working loose. The screws and pins come with the mount.

Remove the rifle from the stock, and place barrel in vise, left side up. On barrel and front end of receiver there is a small index mark, used as a guide for screwing the barrel in. With scriber and straightedge, continue this mark back along side of receiver about four and one-half inches. The screw holes are all to be centered on this line, which is, or should be equivalent to the upper edge of stock at this point.

The under side of receiver plate is milled hollow to fit the curved side of receiver. (On the Noske this surface is flat—a most asinine mistake!) Lay this plate on receiver, with its front end about 1/4 inch back of barrel ring, and try it for fit. If there is any "wobble" between plate and receiver, spot it with lampblack and dress off under side with file until it lays up flat and snug. Now drill No. 2 hole in plate with No. 20 drill; place it in position on receiver and mark position of hole in line previously mentioned. Center punch it exactly on this line and drill receiver. (If hard, spot anneal by either of the methods previously described.) Place plate in place and ream plate and receiver together, with a No. 0 taper pin reamer. Now drill No. 5 hole in plate, center it on line on receiver, drive the taper pin lightly into No. 2 hole, and scribe the position of No. 5 on receiver. Drill and tap this hole for a 10/32 screw. In like manner, we next drill No. 4 hole, ream it for its pin, and then drill and tap screw holes Nos. 1 and 3.

The screws supplied for this plate have heads about 1/2 inch thick, the idea being to cut them down after they are attached. When through with the drilling and fitting, the plate should be sweat soldered in place, with the screws set up moderately tight, and the pins driven in very tight. Grind off protruding ends of pins flush with surface, and polish plate, first taking out the screws. The screw heads may then be cut down to about 3/32 inch in thickness and re-slotted, or they may first be set in very tight (hot), and the heads filed down afterward, omitting the slot. The plate may be left bright, or chased, or it may easily be blued with the No. 1

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basic solution (Chapter 20) without affecting balance of receiver.

The projecting ends of screws and pins must be dressed down inside the receiver, and for this purpose the dental engine with small carborundum wheel is indispensable—in fact, I know of no other way of doing the job. The screws could easily be filed off, but the pins are hard and must be ground.

The Noske mount base is attached in exactly the same manner, except that it usually comes with the holes already drilled, which makes it a little harder to get them lined up to register with the holes drilled in receiver. Moreover, due to the under surface of this plate being flat, it is much more difficult to get it lined up vertically against side of receiver, and it is necessary to use V-blocks and squares as already described.

Both the Noske and the G. & H. mounts have lateral adjustment only, the former by means of two screws set up against each other, the latter by a single screw. Elevation is provided in the scope itself, by raising or lowering the reticule.

While these mounts have much to recommend them, they also leave much to be desired. Their cost—$35.00 each—is in many cases more than that of the scope; hence the total cost of scope and mount often exceeds the cost of the rifle, besides being prohibitive to many. To this cost must be added a charge of $5.00 for attaching the mount, which the gunowner may consider high until he does the job himself—then he'll wonder how they do it for $5.00!

The perfect scope mount has not yet been made; but riflemen are awakening to the value of the scope, and the demand will undoubtedly result in some very satisfactory developments in the near future. Even now I understand that both Fecker and Niedner

are working on improved hunting mounts, which the shooting public awaits with keenest interest.

The Noske and Griffin & Howe mounts are at fault in not having all parts hardened to resist wear. Without such hardening, there is bound to be some change in the point of impact of the rifle sooner or later, to say nothing of the possibility of looseness developing in the mount itself. The lateral adjustment, moreover, is not positive on either mount. The Noske is very hard to align on the target for any given range, due to the difficulty of loosening one screw just the right amount, and setting the other up against it. In the G. & H. mount, the single windage screw does have backlash, any reports to the contrary notwithstanding. And there is no means provided for locking this screw in place, once it is set. Yet in criticising, we must also remember that these represent the best available to date, and we will make them do until their makers, or some others, give us better mounts. And it is to be hoped that the demand will warrant a volume of production that will cut the cost in half.

Belding & Mull have done a pretty good job to date on their

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mounts, which are of the sliding type, not adapted to scopes intended for rigid mounting like the Zeiss and Hensoldt. Moreover, their mounts are reasonably priced, despite the precise workmanship which is unsurpassed by any mounts on earth. I should like to see them bring out a good rigid mount for these two scopes.

TO DISMOUNT THE ELEVATOR OF THE HENSOLDT SCOPE. First loosen the small lock screw on front. Now notice that the elevator disc is in two parts. Remove the two small screws near center of upper disc and lift it off. Underneath you will find a large screw in the center of the next disc. Remove this screw. The inner disc fits the pivot very tightly, and is keyed to the pivot with two small pins. Turn this disc as far to right as possible, then carefully pull straight out, pulling disc off the pivot. The upper end of this pivot is slightly tapered to fit tightly in the hole in disc. If the key pins come off with disc, drive them out with small punch. If they remain in the pivot, let them alone. Lift off the round flat tension spring. Now you will see two more screws holding the frame of elevator to scope barrel. Remove these and lift off frame. Remove elevator screw by turning to left with the fingers. Replace parts in reverse order.

TO DISMOUNT ELEVATOR OF ZEISS ZEILKLEIN SCOPE. Remove the three small screws in elevator disc, and lift off disc. Note one of these screws is longer than the others. Remove the two screws in either end of elevator frame or plate and lift this plate off. Unscrew elevator to left with the fingers and remove. Remove the small top screw just back of elevator screw hole. Replace parts in reverse order.

When dismounting any part of scope, note the grease or wax put in to waterproof the instrument, and be careful not to remove this from any part.

The longer of the three top-plate screws in the Zeiss is intended to prevent the disc being given more than one full turn, this screw striking against the stop screw set in barrel of scope. If necessary to move the reticule more than one revolution permits when sighting in, remove this long screw; after sighting in, place this screw in whichever of the three holes will permit of its resting against stop screw at point blank range.

SPECIAL SCOPE MOUNTS. An adaptation of the B. & M. sliding system mounts to the Zeiss Zeilklein scope, designed by Colonel Whelen, is shown in Figure 183. This is their regular T-H mount with D-C screws, the front and rear rings being integral with the base strip, and all milled from the same piece of heavy tubing. There is a collar clamped to the scope with a stud engaging a groove in mount base, to prevent the scope turning. Whether the scope is permitted to slide in the mounts, or whether this stud also holds it against forward motion I am not sure—either plan would doubtless be satisfactory. This was designed for a 52 Winchester, but would

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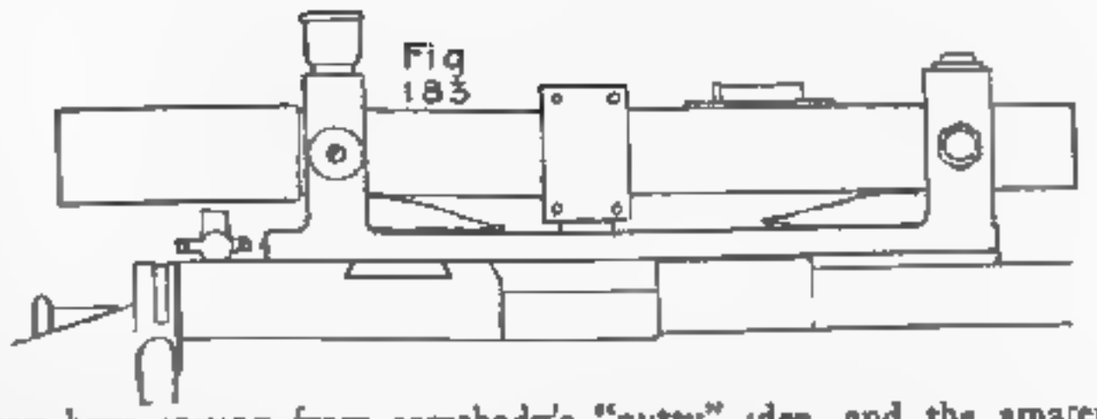
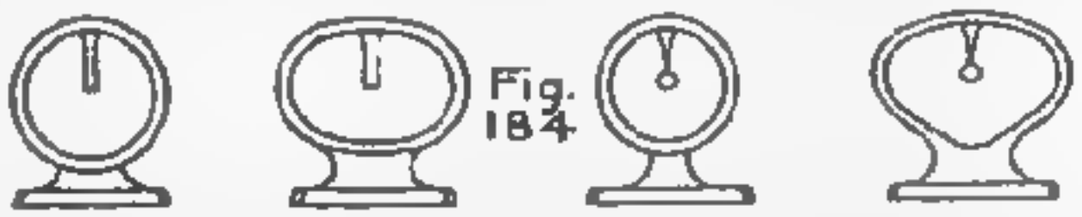
work equally well with a Mode. 30 Remington, or a single shot rifle.

Experimenting with sights, scopes and mounts is a very fascinating pastime for the gunowner. Variations of eyesight, and methods of aiming prevent the possibility of all sights suiting all shooters, or of any sights suiting some shooters. The very best of our existing types



may have sprung from somebody's "nutty" idea, and the amateur should feel encouraged to do all the experimenting he likes in this direction.

In closing this chapter, I submit for public bombardment or acclaim one of my own "nutty" ideas which I have used with success and satisfaction on several rifles, but which I do not use habitually, partly because of the wise cracks which usually accompany its appearance, and partly because I have not yet settled on final dimensions. Several models of this "inverted" type of sight are shown in Figure 184. The idea (nutty or otherwise) is that when aiming at game it is quite necessary if not more so to see what is below the bead, than it is to see what is above. We seldom want to hold



under, but frequently desire to hold over. With this sight, holding over does not in the least obscure any part of the animal, and one can gauge to a nicety just how much higher he is holding. Such a sight must of course be used only with an aperture rear sight. Naturally it would not be approved by those who find the hood a drawback in the woods, particularly if the hood is made large enough not to obscure the field. It seems to me that I catch my aim a bit quicker with this sight than any other, but time will tell. The sight is not on the market, and has only been made experimentally. It might be called the "hold-over" sight—possibly on the assumption that the designer should be confined in the holdover.

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Chapter 30

REMODELING MILITARY AND OBSOLETE RIFLES

IF the reader is of the type who invariably reads the tail end of a book first, he may find it desirable to reverse his usual custom in this instance, and familiarize himself with some of the preceding chapters before going seriously into the subject of remodeling military and obsolete rifles. For to cover such a broad and all embracing subject in a single chapter, giving detailed operations on each and every rifle mentioned would clearly be a task suited to mighty few men—and no boys, and the chapter would lengthen out to an extent exceeded only by some of the shorter sentences in German literature, besides involving much needless repetition.

Having already discussed at length and in detail the various subjects of making, checking and finishing stocks, fitting sights and telescopes, altering barrels, bluing, browning, polishing, and numerous other operations which enter into the making of any firearm, this chapter naturally resolves itself into a general discussion of the remodeling possibilities of various rifles; while the reader, if he has assimilated a reasonable portion of what has gone before, will have no difficulty in understanding what we are talking about, and will grasp the necessity for this or that operation at a glance.

So far as I am aware—and I trust nobody will accuse me of making this as a downright flat footed statement—about the first military rifle to be thus remodeled into a sporting arm in the United States, was the Springfield, which Stewart Edward White carried with him on his first African hunt. Roosevelt used a Springfield in Africa prior to this, but to the best of my knowledge his gun was the straight service model with few, if any, alterations—possibly nothing but sporting sights. The White rifle was remodeled by that illustrious and immortal gunsmith Adolph Wundhammer, late of Los Angeles, following suggestions offered by Captain Crossman, Mr.

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White et al, and with possibly a few of his own ideas thrown in for good measure. Whoever may have been responsible for its development, the fact remains that the resulting arm set the pattern for many others to follow; and barring perhaps a few improvements in stock formation, and of sighting equipment, it has scarcely been surpassed by any of the more costly jobs of recent years.

About this time, or possibly a little later, Colonel Whelen had been writing in some of the outdoor magazines concerning the effectiveness of the Krag on big game, he having been using an "as issued" rifle for hunting in the Philippines. His statements so interested Dr. Paul B. Jenkins, then shooting editor of "Outer's Book" which later was re-christened Outdoor Recreation, that he, being already an ardent admirer of the Krag action and cartridge, forthwith hied him to old Steve Munier, the veteran gunsmith of Milwaukee, and ordered what is believed to be the first Krag sporter.

White's rifle consisted of a service barrel and action mounted in a sporting stock and fitted with a Lyman No. 34 receiver sight,—which I have always maintained was superior to the Lyman 48 for hunting purposes, due to its greater strength and the fact that there is less danger of its coming out of adjustment. The barrel was held to the forend by an inside band such as is still being used. The regular military front sight base was used, although the blade was replaced by an ivory or gold bead. The military rear sight fixed base was left on the barrel, the movable base being merely screwed out, to be replaced when and if wanted. The stock was beautifully shaped, finished and checked, and fitted with sling swivels. The trigger pull was tuned up, and the sights adjusted for the desired hunting ranges.

Dr. Jenkins' Krag job did not include a new stock, the military stock being remodeled and used instead. The alterations to this arm (which was a carbine to begin with, having 22 inch barrel) consisted of removing the rear sight and base, filling in hole in handguard with a piece of walnut, replacing the military front sight with a Lyman gold bead, fitting a Lyman No. 34 receiver sight (Derned if the old timers don't seem to agree with me about the 34!), smoothing up the action, and remodeling the stock. The grip was reduced in front of the comb, deepening the hand hole to make the comb appear higher, and the stock then worked down to the same dimensions as the owner's favorite Parker shotgun stock, so that the two guns handle exactly alike. The stock was checked and refinished, the butt being fitted with a rubber recoil pad. The action was smoothed up, the slack taken out of the trigger, and a set-screw added to make the pull adjustable. Butt stock and forend band were fitted with eyes for sling hooks. This carbine was remodeled in the fall of 1908, since which time it has killed seven deer besides much other game—its best shot being on a deer running at 230 measured yards.

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Since these rifles were remodeled, the cranks in all parts of the country have taken strongly to the idea of building their hunting arms from modern or obsolete military rifles, and have vied with each other in the matter of stock design, sight equipment, fit, balance, and decoration—until it is safe to say that the finest and best all round hunting and target rifles today are based on military actions.

The reason for this is quite evident. Development in the field of ammunition has been largely centered on loads for military use. Our best hunting cartridges are but modifications of those originally worked out for the armies of the world. Increases in velocity and energy, with accompanying flat trajectory, have been first presented in the cartridges made for use in army rifles—and experience has taught that, barring slight differences in bullet construction—these military loads are also best for big game. Without a doubt the two best all round big game cartridges in the world today are the .30-06 and the .30-40. Both have proved their worth under actual hunting conditions in competition with others; and while there are instances when one of the magnum cartridges might prove better adapted to some special use, the two mentioned will hold their own in any company, and successfully account for their fair share of clean kills on all game found in America, and much African and Asiatic game besides. It is a fact worthy of note that most African hunters, while recognizing the need for a very large caliber rifle for the largest game invariably takes along a lighter arm of about the power of the Springfield or Krag, with which he will fire a hundred shots at game to one with the larger arms. The Englishman is partial to his .303 for all-round work, and the similarity of its ballistics to those of the .30-40 constitutes further evidence of the general desirability of this type of load for all round use.

To own a sporting Springfield is a dream that was unrealized by many riflemen who felt they could not afford the cost of having the service arm remodeled by a high class gunsmith; then Col. C. E. Stodter, then Director of Civilian Marksmanship took things in hand and turned out a plain, substantial sporter, without frills or furbelows, yet possessing all of the essentials, and at a price to compete easily with the standard run of factory guns.

The D. C. M. Sporter has brought to hundreds of riflemen a class and quality of arm that they never could have afforded otherwise; it is ready to take to the range or hunting field just as it comes to the buyer. Yet the man who plans to have it further remodeled and "dolled up" a bit, or who perhaps plans on doing the work himself, finds it the best adapted of any military type of arm available. The barrel is already polished and blued—and a good job it is, too. The Lyman No. 48 sight is already fitted, and the arm sighted in at 100 yards. It has the military blade front sight—ideal for target work, although the hunter usually substitutes a gold or ivory bead. It has a plain and somewhat rough stock, with full pistol grip 3 1/2

Upper - The Krag sporter dea gned and made for Dr Paul B Jenkins Center Another sporter job made by using the rifle "as issued" adding sporting sights and checking the service stock Lower- A Mannlicher style Krag with peep sight.

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inches from the trigger, and dimensions that will come pretty close to a perfect fit for 99 men out of a hundred; yet the stock is purposely left very full so that the owner may, if desired, trim it down slightly to correspond with his own ideas. The barrel is star gauged and carefully tested for close grouping; the action is hand finished and all working parts polished to give smooth operation. The trig-

ger pull is usually crisp and clean, requiring a pressure of about 4 pounds—which is from 1/2 to 1 pound heavier than most riflemen desire. It is, however, a far better pull than is usually found on any factory made arm.

The man desiring a specially stocked sporting or target arm of highest quality, without the necessity of mortgaging the old home place to buy it, will make no mistake in investing forty-six dollars in the D. C. M. Sporter, and discarding the stock, which has a selling value of only five dollars—and anyhow, you can keep it for a "spare" or sell it to a friend. By buying the sporter instead of the service arm you not only get a better, more accurate, and slightly heavier barrel, you also avoid the necessity for polishing and bluing, which adds something like nine dollars to the cost of the job, and you get the Lyman No. 48 sight, which would cost you $11.50 if bought separately. In other words, the original forty-six dollar investment represents about the sum total cost of the arm provided you make the new stock yourself.

Outlined briefly, the remodeling of the D. C. M. Sporter into a rather more handsome, but not necessarily better shooting rifle, will consist of the following operations, all of which have been explained in full details in previous chapters.

1. Remove military front sight and attach Lyman, Marble, King, Sheard or Western gold or ivory bead; or, remove front sight movable stud, and attach Lyman No. 7 or Watson No. 2 hooded front sight, or the Watson No. 1, or the Western Full-Block sight.

2. Discard old stock and make new stock from fancy grained walnut or other wood to your own dimensions, with or without cheek piece; checking and finishing it in any manner desired. You may use the original barrel band, or you may make an inside band with stud screw for detachable swivels as described in Chapter 24; and you may use the original buttplate, or a Mannlicher-Schoenauer plate, a Mauser, or any other plate desired, or fit a rubber recoil pad. The forend tip may be plain, swobble, or horn tipped.

3. The Lyman 48, being the best for both hunting and target work, will usually be retained. Its micrometer adjustments give accurate values for each click on the adjusting screws, and to date a better all round target sight for the Springfield has not been produced. For an arm to be used only in the hunting field, the Lyman No. 34 is better in the hands of the practical shooter who cares nothing for half splitting adjustments, and who does not understand them, because its construction makes it less liable to damage from accident or abuse. But since the 48 is already on the rifle, and since the elevation may be firmly locked, and since with this sight it is easy to make adjustments for variations in ammunition when and if desired, there is very little reason for discarding it in favor of the cheaper sight.

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The magazine cutoff is of little or no use on a hunting arm, and the usual practice when remodeling the Springfield is to make it inoperative. Omit the cutoff notch in left side of stock, and round upper edge of stock so that cutoff may just be turned horizontally as required to remove bolt. Grind rear end of magazine follower to a bevel extending forward about 5/8", so that the bolt, in closing, rides up this bevel, forcing follower down, instead of being held open by the follower. The beveled portion of follower must be polished very smooth, and corners well rounded.

The foregoing are absolutely all the changes needed to make an arm fit for the most "highbrow" company of the D. C. M. Sporter. Additional sighting equipment if desired, should consist of a Hensoldt or Zeiss Zeilklein or similar glass on Noske or G. & H. mount, for hunting only. If the arm is to be used largely for target work, the glass should be a Winchester A-5, or a Fecker scope and mounts.

As a general rule, when remodeling a D. C. M. Sporter, the front sight ramp is omitted, since its attachment necessitates reblueing the barrel. My suggestion would be to pass up the ramp, then, when a year or so of use has marred the finish and it needs bluing, is the time to think of a ramp.

A sporter as above outlined will weigh somewhere in the neighborhood of 8 1/2 pounds—which is about light enough for any man with sufficient muscle and guts to go into the woods for big game. If he can't carry this much gun, he should stay home in bed and have a nurse feed him his milk through a straw. It's fine to talk about "that nice little featherweight"—and it sure is fine to carry on the trail; but when you sight the big buck unexpectedly at the end of a steep climb, when the old heart is hammering away and the breath coming—like the little boy—in short pants—then the heavier gun settles down quickly for the shot while the featherweight wiggles and wobbles all over hell's half acre. For which the said buck should give thanks—and probably does.

There is something to be said in favor of the light rifle for the man who makes a pack trip alone, and where every ounce counts. The man who does this, however, has very likely had sufficient experience to teach him the limits beyond which a rifle cannot be reduced without seriously impairing its efficiency; and he will not order his Springfield or other rifle of equal power, to weigh less than seven and one quarter pounds.

The owner of a service Springfield "as issued" or of a National Match rifle with military stock has a good foundation for a splendid sporter; however it will require more work to convert it, and if the job is turned over to a good shop, the cost will necessarily be greater than for the job on the sporter.

If one is interested only in efficiency, and considers good finish as of secondary importance, he can easily remodel his service Springfield at comparatively small cost, as follows:

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1. Remove the folding drift slide from the rear sight movable base by driving out the pin, and replace with the King folding leaf sight which is made for that purpose. This permits lateral adjustment by means of the regular windage screw, and the leaf sight is adjustable for serious elevation by means of a small screw in the notched slide. Replace the military front sight with any standard make gold or ivory bead.

2. Cut off forend about 2 1/2 inches ahead of lower band; fill in the channel with a piece of walnut, and shape forend tip as desired. Cut off hand guard flush with forward edge of lower band. Build up the comb of buttstock as described in Chapter 14, and add a pistol grip if desired. Lengthen stock by means of a rubber recoil pad. Reshape and refinish stock.

If one desires to remodel the service rifle without polishing and rebluing the barrel and action, the following will turn it into a serviceable hunting arm at a minimum of time, cost and labor:

1. Purchase the following parts from the Director of Civilian Marksmanship:

1 Pistol grip stock, Model 1922, Sporting type, for Model 1903 rifle, without rear sight base	$ 3.00
1 Buttplate, Model 1922, with screws	.50
Packing charge	.25
Total	$ 3.75

2. Make, or have a machinist make two collars as shown in Figure [illegible], Chapter 24; one to fit the barrel at breech just ahead of receiver and the other to fit it about where the forend swivel is to be located. Remove front sight movable stud, and notch the smaller collar so it will slip over the stud, and drill collar for a forend swivel screw, made as described in Chapter 24.

3. Make a handguard from a piece of walnut, roughing out the groove slightly larger than the barrel; make this piece with a tenon on each end to slip under the overhanging edge of the two barrel collars. The fixed base of the military rear sight is of course removed before putting on the breech collar. The lower half of both collars are inletted into the wood of the forend. Drill a hole for the forend swivel screw, then dress off the shoulder at front of forend, shape tip as desired, polish and oil. The handguard covers most of the roughness of the barrel and makes refinishing unnecessary.

4. Remove military front sight from movable stud, insert gold or ivory bead as desired, and replace movable stud. Attach Lyman No. 48 or No. 34 or other suitable receiver sight.

The foregoing covers all of the essentials. Probably the owner will decide to reshape the entire stock somewhat, and give it a good oil finish, he may also want to check it at grip and forend. If he should study the wood of the stock carefully, however, before attempting a checking job, as many of these stocks are so soft that the wood "fuzzes" up and will not check cleanly. Use a special cutting not less than 16 lines to the inch.

A rifle made up as above described will weigh a few ounces less than the regular D. C. M. sporter, as the service barrel is slightly thinner just forward of the breech.

Now we are ready to consider the making of a really first class sporter—that is, completely remodeling the arm from start to finish. If you have a service or National Match rifle to begin with, and want to use it, all right. It is poor economy, however, to buy the

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entire rifle and then discard many of the parts. If you desire only enough parts to make up a high grade sporter, or to send to a gunmaker for assembling and stocking, order the following from the Director of Civilian Marksmanship:

	N. M. Grade	Service Grade
1 barrel and receiver assembly	[illegible]	12.16
1 bolt assembly	3.76	2.43
Extra for fitting bolt to receiver and adjusting headspace	[illegible]	1.00
1 bushing, guard screw	[illegible]	.07
1 Catch, floor plate	[illegible]	.25
1 cutoff	[illegible]	.33
1 Ejector	[illegible]	.20
1 Follower	.32	.85

1	Guard, trigger		2.25
1	Pin, ejector		.02
1	Pin, firing assembly (Service) or		.69
1	Pin, firing, assembled to headless cocking piece, (N M.)	.35	
1	Pin, floor plate catch		.01
1	Pin, sear		.02
1	Pin, trigger		.02
1	Plate, floor		.22
1	Plunger, cutoff		.01
1	Screw, cutoff		.03
1	Screw, guard front		.03
1	Screw, guard, rear		.05
1	Sear		.24
1	Spindle, cutoff		.06
1	Spring, cutoff		.01
1	Spring, floor plate catch		.01
1	Spring, magazine		.11
1	Spring, sear		.02
1	Trigger		.32
	Total	$25.15	$1.45
	Packing charge	1.35	1.34
		$26.50	$2.79

This includes all essential parts, and nothing that is not needed. The general proceedings in building up the rifle are as follows:

1. First strike and polish the barrel, polish receiver, magazine, floor plate, and other working parts. If you buy the National Match bolt assembly, it comes already polished.
2. Make new stock to specifications desired. Fit buttplate, forend tip (if one is used), and pistol grip cap.
3. Fit Lyman 48 or other receiver sight to action, and notch stock to receive the sight base.
4. Start oiling the stock, and continue this job while finishing up the metal work.
5. Make and fit swivel band to barrel.
6. Make and attach front sight ramp. Solder a temporary lead or brass sight to ramp.
7. Assemble rifle, even if stock oiling is not completed, and sight in for elevation. Disassemble, and continue the oiling of stock.
8. Cut dovetail in ramp and fit front sight to correct height.
9. Repolish barrel where discolored by soldering ramp, band, etc., and blue all metal parts.
10. Check stock as desired, complete the oil finish, and assemble rifle.

By doing the work yourself, the actual cash outlay for stock blank, sights, buttplate grip cap, oil, sandpaper and all necessary parts and materials will probably not exceed $25.00 to $30.00—which includes the cost of having a ramp blank milled out at a machine shop.

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Thus you have a high grade beautiful and efficient sporting Springfield, for around $50, the price of a perfectly plain factory made arm. This does not include any allowance for your time, which of course would be considerable—but then think of the fun you will have doing the job!

A similar arm, built to your specifications by a competent gunsmith will cost from $60 to $150 or perhaps $200 in addition to the cost of the original Springfield parts. The man who has never built his own sporter may think the gunsmith is "holding him up" on the price. If any one feels that way about it, he is cordially invited to build his own. With care and patience he will, in all probability turn out a good job, and one that he will have cause to feel proud of. But never again will he think of the gunsmith as a financial pirate; he'll realize that the job is worth every cent charged for it—and he'll earn the gun if he builds it himself.

It is not necessary to dwell at length on the various alterations made upon Springfields by their owners to adapt them to their ideas of what's what. The accompanying illustrations may offer some helpful suggestions, the carrying out of which will be fully understood if you have read the rest of this book.

One thing not touched on previously is the bending and otherwise ALTERING OF BOLT HANDLES. Generally speaking, such alterations are not to be advised, due to the danger of ruining the bolt by heating. Often, however, it is necessary to either bend or grind away part of a Springfield bolt to enable it to clear a telescope sight. Figure 186 shows a lever made for bending the bolt handle down and back as required. This is made of a bar of 5/8 x 1 inch cold rolled steel, notched as shown, and the edges of notch filed smooth and rounded. Two of these will be required. The bolt should be well wrapped in soaking wet rags, and firmly clamped in the vise. It will be necessary to use one or two short lengths of square steel stock in the vise jaws to hold the bolt as required. Have an assistant stand by to renew the water on the rags near the bolt

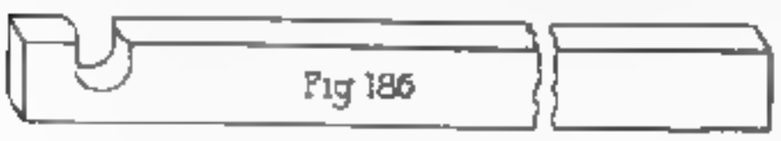

Fig 186

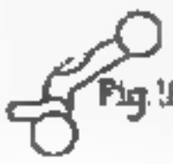

Fig 187

handle. Use only an acetylene torch to heat. Heat bolt handle to cherry red. Then take the two notched levers, one in each hand, and bend handle as desired. There must be no bend or twist in the flat portion where handle joins the bolt. Hold this portion firmly in the notch of one lever, while bending the lower part of bolt handle with the other. If desired the knob may be bent down very close to the stock, and the under side of knob ground flat for

[redacted]

clearance. This is sometimes done when the rifle is to be carried in a saddle scabbard. After bending, let the handle cool for several minutes before dipping in water to cool it completely—but keep the rags wet constantly, to prevent the balance of bolt from heating up.

The heating has left the bolt handle soft, so the knob may be file checked or stippled if desired. Often the underside (particularly if it has been ground flat) is checked, and the round side left smooth. All this is purely a matter of choice—personally I prefer a full round smooth bolt knob which rolls easily in the hand.

Do not make any attempt to re-harden the bolt handle, or your efforts may result in cracking the bolt. Leave it soft—there's no wear on it anyhow. Just dress it up smooth with a file, polish and blue it. Blue the entire bolt if you like, or blue the handle only, using the No. 1 Hot bluing solution given in Chapter 20. Some of the solution will run onto the body of bolt and make spots, but these are easily polished off afterward.

Some gunsmiths, particularly those who go in for light weight "de luxe" Springfields, are given to filing down the bolt handle to about half its original size. I would most emphatically advise against this. In the first place, the heating naturally removes some of the stiffness of the handle. The thin, skinny handle may look a little better on a very light rifle—but what if a shell sticks sometime, and you have to use your shoe-heel or a stick of stovewood to open the bolt? I have had to do this very thing more than once. *Leave that bolt handle as nearly its original size as you possibly can.*

Figure 187 shows a bolt handle with a round notch ground in it to clear the large eyepiece of a Hensoldt Zial Dialyt scope. This

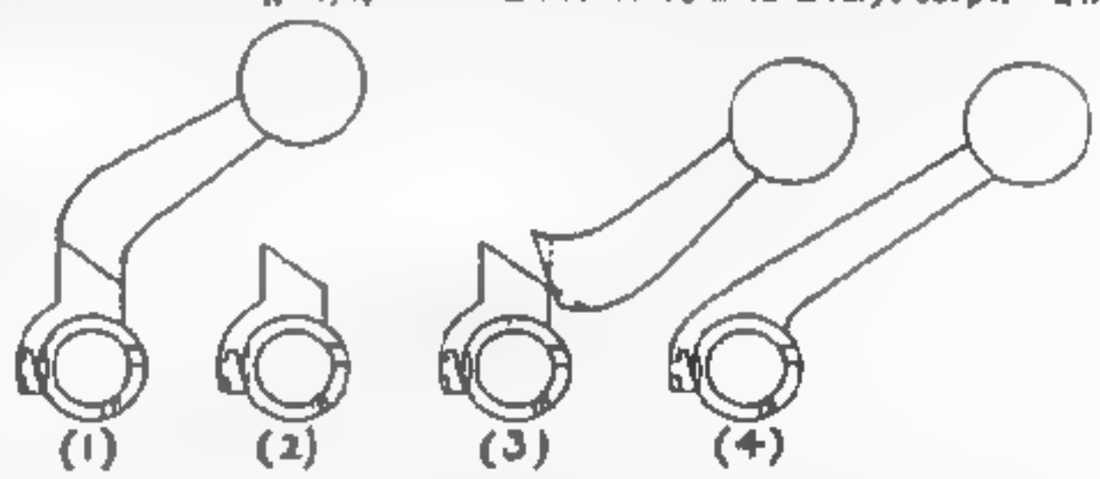

Fig. 188

is ground in on a round edge emery wheel, without heating the bolt at all.

Figure 188 shows an alteration described some time ago in the American Rifleman by H. A. Stillwell, to permit the use of a lower scope mounting on a Springfield. The bolt must be wrapped in wet rags as before mentioned, and the handle heated to anneal it. Then saw off on the line as shown in the drawings (1) and (2). Reverse the handle as shown in drawing (3) and weld with acetylene

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torch, building in new metal with good carbon steel welding rods. The pointed projection is then ground off as shown by dotted lines in drawing (4), and the handle filed smooth and polished.

I am showing this alteration for what it may be worth to the reader, and would not hesitate to do the job for anyone who wanted it done. The strength would be somewhat reduced, of course, but the handle should be amply strong for ordinary use. Personally, my bolt handles will not be heated. The softening of the cocking cam, while not materially affecting the work of the bolt, will in time result in wear which will prevent the smooth, fast opening action possible only in a well hardened bolt.

The foregoing instructions will apply generally to almost any bolt handle that is to be slightly bent from its original shape. It is seldom necessary to bend the Krag handle back, although it may in some instances be desirable to turn it a bit closer to the stock on a saddle gun, and the same may apply to the Remington Model 30, the 54 Winchester, the Newton—in fact any bolt handle that

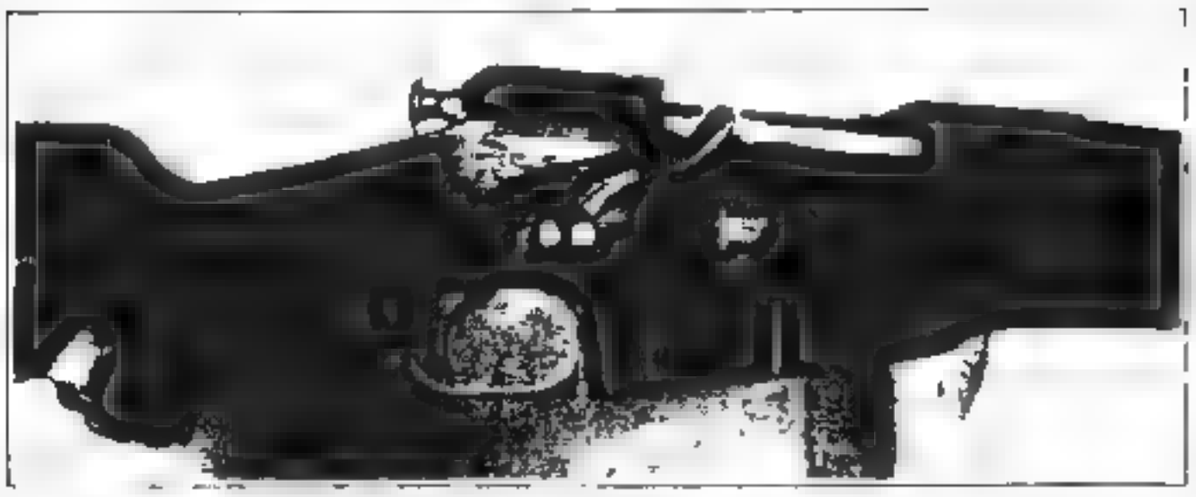

Fig. 189

does not suit the owner can be considerably altered within reasonable limits. In this, as in other alterations, *MODERATION* should be the order of the day. Don't run things to extremes or you will soon become sick of the gun.

Figure 189 shows a simple, yet very effective alteration on the bolt handle of the Russian 7.62 mm. rifle. In this case—and in some Mausers and Mannlichers as well—the handle sticks straight out from the receiver like the springboard down at the old swimmin' hole; and it is so far forward that only a man with gorilla arms can reach it without taking the piece from the shoulder. Bending down the handle helps but little—it should be lengthened and bent back toward the trigger far enough so that it may easily be reached without taking the arm from the shoulder.

On some rifles this is accomplished by cutting the bolt handle in two between knob and bolt, and welding in a piece of steel. On

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the Russian, however, I find it best to cut the handle off right up against the bolt, and make and fit a new handle. The handle is attached to a rib which lies on the right side of bolt when closed. Saw off even with the rib, then drill and tap a hole in rib—which hole should not go clear through into the inside of bolt, but will not hurt the job if it does. Saw off the knob from the old bolt, drill and tap it for a 3/8 to 7/16 inch rod with 24 to 32 threads. Before shaping the rod for the new handle, bend a piece of heavy wire to the desired shape, and use this as a guide in forming the handle. Drill rod may be used for the handle, but cold rolled steel will do as well. Cut to length, bend it to shape, and thread both ends—the one to screw into the knob, and the other into the bolt. Set the knob on with a rust joint, or solder. Set the other end into the hole in rib on bolt, so that it is very tight when handle is in desired position. This joint should then be soldered. Heat the bolt near the hole hot enough to melt the solder and keep it melted for a few minutes. Tin the inside of hole; also tin the threaded end of handle; screw it into place and when the solder cools it is there to stay. Clean off excess solder, polish and blue. The appearance of handle will be improved if it is slightly tapered toward the knob.

This heating of the bolt does no harm on the Russian, as the locking lugs are made on a separate piece which attaches to the forward end of the bolt proper. It is of course necessary to *completely* dismount the bolt before heating.

REMODELING THE KRAG: Like the Springfield, the Krag Jorgensen is easily remodeled in a handsome, serviceable sporter, with much or little work or expense, according to the desire of the owner. Next to the Springfield it is perhaps the most practical hunting arm available today for all round woods use, and certainly one of the cheapest in cost. At this writing the Director of Civilian Marksmanship is selling good serviceable Krags to N. R. A. members for $1.50 each! And while some of the barrels show a very small amount of wear, they also bear unmistakable evidence of that thorough and frequent cleaning which is exacted of all of Uncle Sam's boys. Of the many Krags that I have owned, handled and remodeled for others, I have never seen one sold by the D. C. M. on which the barrel was not in pretty good shooting condition—and some of them are still good as new!

There's something about the old Krag that a real rifleman can't help loving. It's strong and substantial; stands abuse that would wreck many high priced guns; the bolt is easier working than the best match Springfield, and plenty strong enough for any load it was designed to handle up to 43,000 pounds breech pressure. Its design also permits a much lower mounting of telescope sight than any Mauser type action unless it is the Model 30 Remington. The lines of the receiver are clean and graceful, and there are several good receiver sights adapted to it.

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As the Krag comes to the purchaser from the D. C. M. it is rather long and ungainly, but it need not remain so for very long. The simplest remodeling job consists of merely cutting it down to a carbine, the general details of which are about as follows:

1. Cut off enough of the barrel to get rid of the front sight base. Then slip on a Springfield fixed stud and peen and stretch the band to a snug fit on the barrel at a point 1/4 inch back of the length desired—22, 24, 26 inches, or whatever length you decide on.
2. Saw barrel to desired length and crown muzzle.
3. If inside barrel band is to be used, make and fit band in place on barrel. The regular military band with swivel may be used, in which case it is not put on until the job is finished and the rifle finally assembled.
4. Sweat or pin Springfield fixed stud in place as described in Chapter 29.
5. Remove military rear sight and fill holes with dummy 8 x 32 screws, headless. If preferred the regular military rear sight may be used in lieu of a receiver sight.
6. Attach Lyman No. 33, 34, or 48 receiver sight, Marble No. KR receiver sight, or a Lyman or Marble cocking piece sight. (Latter not recommended, due to inaccuracy resulting from unavoidable play in cocking piece.) Or, make and fit a fixed peep on bolt sleeve, as described in Chapter 29. There is very little play in the sleeve, and unlocking the safety usually forces the sleeve to the same position each time.
7. Lighten trigger pull as desired. The action of a Krag needs little if any smoothing up—they all work like greased lightening.
8. Cut off forend two or three inches ahead of swivel or barrel band, and shape up tip as desired, after filling in the hollow under barrel with wood as described in Chapter 14.
9. Remove marks, dents and scratches by lightly rasping, filing and sanding stock all over, then oil finish.

A more complete job that will result in a finer appearing, better fitting and better handling rifle, will involve the following:

1. Cut barrel to desired length, strike and polish barrel, polish receiver and all metal parts.
2. Make and fit band for holding a Lyman No. 6 or similar folding leaf sight, and fit this band over rear sight screw hole. Fill other screw hole with dummy screw filed down smooth with surface of barrel and polished. Make and fit swivel band; make, fit and attach front sight ramp.
3. Attach receiver or other rear sight desired. Attach scope blocks if wanted.
4. Build up higher comb and pistol grip as described in Chapter 14; fill in grooves in handguard. Shape up stock as desired, oil finish, and check.
5. Reblue all metal parts.

"The world is so full of a number of things" as the poet says, which can be done to a Krag, that it is not necessary to enumerate them; one of the beauties of home gunsmithing is that a man may turn himself loose and plan his gun to be a bit different from the other fellow's. The attached illustrations will probably suggest other changes that may suit the reader still better.

A word of explanation of the one stocked flush to the muzzle, Mannlicher style, may be in order. This is merely the service stock worked over slightly, as the owner likes a straight grip, and did not care to go to the expense of a new stock.

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A Springfield fixed stud was attached so that its front edge was exactly at the 22 inch mark on barrel; the barrel was sawed off flush with end of band, and band and barrel crowned as one. A ramp can be attached and finished in the same manner if preferred, and will greatly improve the appearance of the rifle. A steel muzzle cap for the Mannlicher-Schoennauer carbine was then enlarged inside slightly to fit over the sight base band, which was filed down somewhat thinner than it was originally. The forend was sawed 1/4 inch back of muzzle, and the hollow under barrel filled with walnut. The muzzle cap was then fitted to end of forend. A 2 x 56 countersink head machine screw holds the cap in place, the screw turning into a small brass nut let in flush with inner surface of the forend. The forend was then dressed down to a straight taper from swivel band to muzzle cap, and entire stock smoothed up and refinished.

The Krag receiver is square and sharp at its forward end, somewhat detracting from the appearance of the finished rifle unless this shoulder is rounded, or else covered up. The handguard is easily remodeled as shown in Figure 106 (Chapter 14), by blocking in the rear sight opening with walnut. File the edges of this hole straight and flat and undercut at each end with a 3 square file. Bevel the ends of a thick block to fit snugly; clean handguard of grease and oil with hot lye or sal soda solution, rinse, dry, and set

in the block with du Pont Cement, and clamp in vise 48 hours to dry hard. Be careful not to give it too much pressure in the vise as the handguard is just a thin shell of wood and easily broken. The projecting outer portion of the block may be held in the vise while the inside is shaped with a hollow chisel to conform to the inside shape of the guard. Then snap guard onto the barrel, after sawing off most of the projecting wood, and shape up with rasp, file and sandpaper. The top of handguard may be finished smooth, or scored or checked if desired. A row of parallel lines running lengthwise on top are easily cut with the checking line spacer, giving an attractive appearance

If the handguard is not desired, the sharp shoulder on receiver is easily removed. Chuck the barrel in the three jaw lathe chuck, the barrel being inserted through the hole in spindle, leaving the receiver and about 6 inches of barrel ahead of the chuck. If the receiver is very hard use a high speed cutter to turn off the shoulder, or use the grinding attachment to round it up as desired.

In Chapter 24 two types of band are described which may be easily made and fitted around the barrel where it joins the receiver, thus eliminating the objectionable shoulder without turning it off.

The Krag having a worn out or rusted barrel is not at the end of its career by any means. Simply order a Springfield barrel from the D. C. M. preferably choosing the sporter type of barrel, costing about ten dollars. Send it with your action to Neidner or any other

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reliable barrel maker equipped to do the work, and have it cut off slightly at the breech and rechambered for the .30-40 cartridge, and fitted into the action. *Don't trust some jackleg who thinks he can do this job.* The correct headspacing is just as important in a Krag as in any other rifle, and the job is one for experts only. Neidner's price is only $6.00, and it is worth the cost.

Now, if you want a really fine, flat shooting, high velocity small bore rifle, have Neidner make you a special barrel chambered for the .25 Krag-Neidner cartridge, which is really a .30-40 case necked to 25 caliber, loaded with a 100 grain bullet. Here is a thoroughly modern load, ample for anything up to deer, and splendidly adapted to open country shooting by reason of its very flat trajectory. This must not be confused with the Roberts load recently developed, as the latter is made by necking down the 7 mm. cartridge, and can only be used in the Springfield, Mauser, 54 Winchester, or Model 30 Remington action.

A tip: Whenever you plan a job involving a new barrel, get the old barrel out the action, and inlet the action only into the stock before the new barrel is fitted. It is much easier to inlet a stripped action, and you will get a more nearly perfect fit. After the barrel is in the action, it may be gradually bedded, working the channel forward from the receiver mortice toward the forend tip.

Figure 190 shows a simple method of making a Mannlicher style Krag stock devised by Major R. H. Lewis, U. S. A., in which the regular Krag upper band was used. The band was cut in two as shown in the sketch below, and only the forward half used, the

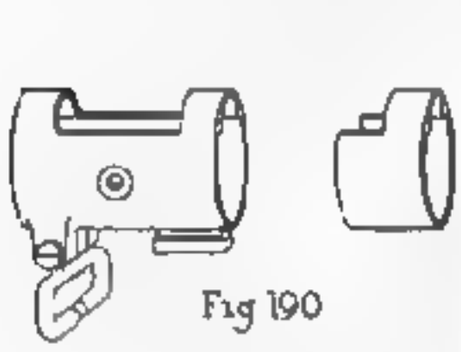
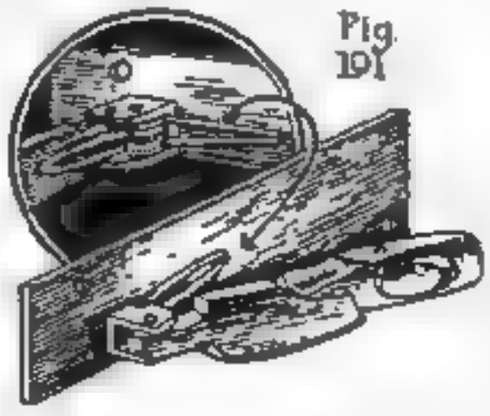


Fig 190

Fig 191



bayonet stud being cut off and bottom of band rounded up and polished. The band is held in position by a small wood screw underneath. Major Lewis used a Marble Duplex front sight dovetailed into the barrel. A Springfield front sight base or a ramp could be used as well, if desired.

Some shooters object to the projecting box magazine on the side of the Krag, claiming that it interferes with carrying the arm in the field. I do not find this much in the way, but then neither do I particularly object to the Lee type of magazine such as is found on the Lee Enfield and the Russian rifle—while others cannot tolerate it. Anyhow, if the Krag magazine takes the joy out of life for you, by all means get rid of it—no trick at all if you work carefully and have patience. Figure 191 shows an alteration suggested by Mr. John C. Harris in the American Rifleman.

First remove the magazine and all working parts. The projecting hinge portion of receiver is then ground down flush, and a side plate made of 3/32 inch cold rolled steel. The hinge for the magazine follower is then filed from tool steel or drill rod, and screwed or spot welded in position. The end of the follower is cut off and pinned into this hinge, with the spring, which is made of piano wire bent as shown in the sketch. The side plate is attached to the opening in the receiver with 8 x 40 countersink head screws. The

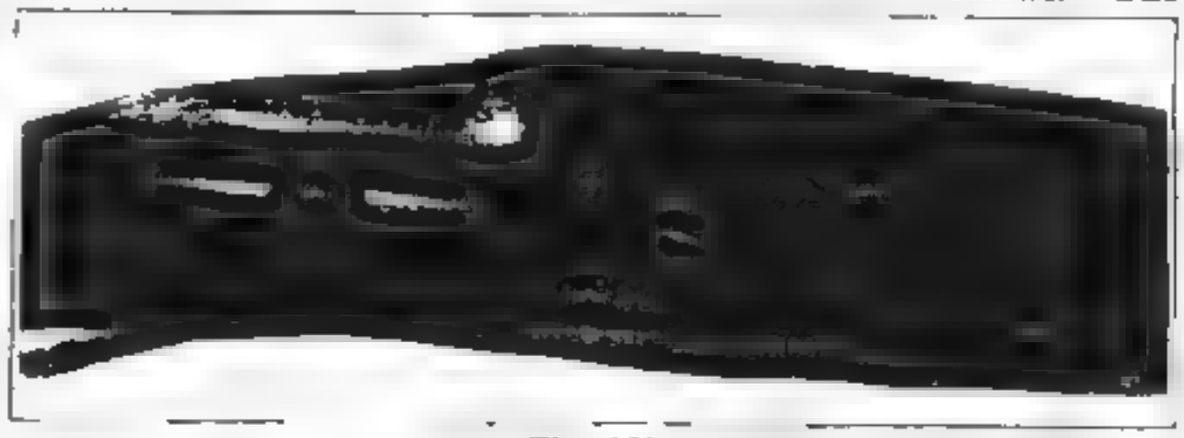


Fig. 192

completed action is then inletted in the usual manner, except that the wood is not cut away on the right side. The cutting away of the left side of stock may also be omitted if desired.

Figure 192 shows a stock which I made for a party who objected to the left hand side plate showing, claiming it weakened the stock. I doubt if the thin shell of wood over the side plate really strengthened it much, but it is satisfying to know the stock can be made in this manner if desired. At least, the stock is somewhat stiffer than the one made in the orthodox manner, but it is still necessary to tie the forend to the barrel with a barrel band.

The principal difficulty encountered in "flushing" the Krag magazine as just described is that of locating the exact position of the follower hinge on the side plate. Unless this is in exactly the right place the cartridges will not feed correctly. After making the side plate, and drilling the screw holes, make the hinge piece, but do not drill the hole in plate for attaching hinge. Instead, soft solder the hinge to the plate in what looks like the correct position, screw on the plate and try it. It may be necessary to shift the position of hinge and re-solder several times before getting it just right. Then a small hole may be drilled through plate into hinge, and a pin inserted as a guide. After which remove the follower, pin and spring, and attach the hinge permanently by screw, spot welding, or hard brazing.

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THE RUSSIAN 7.62 MM. RIFLE, or Three-line Nagant. Some few years ago there were two companies—the Remington Arms Company, and the New England Westinghouse Company, building the above rifle on contract for the Imperial Russian Government, and everybody was happy as the day is long. Then, sad to relate, the long whiskered gentry known as the Soviet went in and sort of took things in hand, and the companies found themselves possessed of many thousands of finished Russian rifles and un-assembled parts that they couldn't very well dispose of, together with certain contracts that might have been useful for shaving paper if they had not been so stiff. Shortly afterward, our own government having decided that peace at any price wasn't worth what it cost, Uncle Sammy began mixing it with the Dutch, the while facing the sudden and unexpected problem of arming his newly recruited fighting men. Springfields could not be built fast enough for all the troops. Remington and Winchester were tooled up for the new British Enfield, so contracts were placed with them for Enfield rifles slightly altered to handle the .30-06 cartridge—the newly born rifle giving splendid service throughout the war. But both Enfields and Springfields were needed in the field, and could not be spared for training all the new units—at least it was feared they could not. So Uncle Sammy, having the interests of home industry at heart, promptly made a deal with the aforenamed concerns to take their surplus Russians off their hands—at a most reasonable figure,—with the idea of using them for preliminary training of troops. Happily the Marines won the war before it became necessary to use any of these crowbars, for which let us

pause and give thanks. Now the same Uncle Sammy is dispensing them to us at the very modest sum of three dollars and thirty-four cents—for which let us give thanks once again!

For while the Russian Rifle is without a doubt the gosh-awfulest looking contraption that ever burned powder, it nevertheless constitutes the foundation for a splendid hunting arm, if one cares to take the trouble to rebuild it.

It uses a rimmed cartridge firing a bullet of 145 to 150 grains weight, 7.62 mm. or about 30 calibers; at a velocity of 2900 f. s.; and the Remington Arms Company and the United States Cartridge Company both make ammunition for it with good hunting bullets. The groove diameter is about .313—a little large for the 150 gr. Springfield service bullets, although these do quite well in it. The bolt is very strong, the lugs being noticeably larger than our Springfield or Enfield lugs,—a splendid idea, since the Russian receivers do not seem to be hardened.

The bolt handle sticks out like a sore thumb, and is awkward to use, but can easily be altered as desired, this having been explained earlier in this chapter.

The Lyman Gunsight Corporation has adapted their No. 36 re-

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ceiver sight, (originally made for the Mannlicher) to this rifle; and while it may seem foolish to pay $10.00 for a sight for a $3.34 rifle—it isn't nearly so foolish as it sounds. *Any Lyman sight is worth its price on any rifle,* regardless of race, color, or previous condition of servitude—and that's that.

One can do almost anything he wishes in the way of remodeling the Russian. Build up and reshape the old stock, as described in Chapter 14 or make a new stock if preferred; cut the barrel to any desired length; leave on the military rear sight, or strip it and put on a Lyman 36 as a Christian and a gentleman should. To remove the rear sight base, heat in blow torch until the solder melts, and drive it toward the muzzle; there is a dovetail milled on the barrel which must be filed off and polished, after which the bright spot may be blued by "lamping"—See Chapter 20. Put on a Springfield front sight base with a Western Full Block sight or a Lyman or Sheard gold bead, or use any of the standard base sights dovetailed into the barrel; carry the wood to the muzzle, or cut it back in a regular sporter forend.

One word—forget about "Russian-Springfields," and such like advertising phrases used by certain junk dealers. A Russian is a Russian—and a Springfield is a Springfield—and never the twain shall meet. I can't imagine the said junk dealers knowing much—or caring much either—about little matters like headspace adjustment; and besides the Springfield barrels they use on their Russians are worn out. "Ask the man who uses one." If you want a Russian, and can't afford a Springfield—then buy a Russian and use it as such. It's a good cheap rifle, and a good dependable cartridge. If you want a Springfield, don't kid yourself—but buy a Springfield and pay the price. Don't be like the Scotchman who, seeing himself about to be run over by a steam roller, turned on his side, so that his pants would be pressed for the funeral.

THE ROSS MODEL 5, Caliber .303 British. Just how and why the United States Ordnance Department happened to have these arms on hand and for sale I do not know; presumably they were purchased second hand as reserve rifles for training troops early in the war. They have been used, but most of them are in as good condition as the Krags.

The Ross action is a "straight pull," i. e., it is not necessary to raise the bolt handle to unlock the bolt. Instead it is pulled straight back, and pushed straight forward to eject and reload. The bolt operates inside a spirally fluted sleeve on the well known principle of the spiral screwdriver; and the forward motion of the sleeve turns the two large strong lugs into their recesses in receiver as surely as turning down the bolt handle of a Springfield turns the lugs into place.

The Model 5 Ross is an entirely different mechanism from the Model 10. In that model there were once some rifles made that

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were not fool proof, in that the bolt could be assembled with the lugs in the wrong position so that they were not locked when the bolt was closed. Some faces and other things were blown off, as a result, I understand—since which time certain parties have been carping on the general undesirability of all Ross rifles, alleging that they were more dangerous to the man behind than to him in front.

I have no argument with those who believe the Ross Model 5 to be unsafe. I don't know whether it is safe or unsafe. I never saw it used in action, and have no firsthand record of any Model 5 bolt blowing out and killing or injuring anyone. The sum total of my experience with the Model 5 covers about a dozen rifles, five of which I have owned and shot, and three of which I still have. The others I shot also, and witnessed their shooting by their owners. In no instance have I seen one of the bolts blow out, nor have I known of one blowing out, nor have I observed any signs of one threatening to blow out. The nearest thing to an accident with a Model 5 Ross I ever saw was a bolt which partly opened after having been shot all day. Investigation disclosed that the shooter had been dipping his bullets into vaseline to prevent metal fouling; and when I examined the bolt and chamber I found everything thickly coated with grease, so that the back thrust of the cartridge against the bolt head must have been at least 50% greater than normal. A Springfield, or even a Mauser (which some of our alleged experts claim is so much stronger) would be expected to let loose under such circumstances. In fact, the blowing up of several Springfields was traced to the use of Mobilubricant some years ago, and the practice discontinued for this reason. When the shooter above mentioned cleaned out the grease from chamber and action of his Ross, the bolt stayed "put" and no trouble has been noticed through hundreds of rounds fired afterward.

The .303 British Cartridge is almost identical in ballistics with the .30-40, which means, that with suitable hunting bullets it is a fine load for all American big game. The ammunition is made by all cartridge companies in this country. Moreover, the action of the Ross Model 5 will handle the .30-40 cartridge perfectly, so it is an easy matter to have a Krag barrel fitted, or a Springfield barrel rechambered for the .30-40 cartridge. It is highly important that the work be done by a competent barrel maker, and headspace adjusted to .004" or less.

The same suggestions applying to other military rifles apply to the Ross when it comes to remodeling it into a Sporter. The barrel is 28 inches long, and may be cut to 22 inches without greatly affecting accuracy. In this length it makes a handy saddle gun. The Springfield fixed stud is too large for the Ross barrel, so it is necessary to make one from Shelby tubing, or to ream the original sight base a trifle and use it. Or, make a ramp of the correct size to fit the shortened barrel.

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The military stock is rather better than most in shape and size, and may be dressed down to a fairly good sporting stock with a little work, and checked and polished as desired. Next to the German Mauser, the Ross is perhaps the best shaped of all military stocks.

The forend can be cut off a couple of inches ahead of swivel band, or carried out to the muzzle as desired. The upper band can be altered into a muzzle cap by cutting it in half as already explained in connection with the Krag. To remove the Ross upper band intact it is necessary first to remove the front sight base. This is soldered to the barrel and may be removed by heating until the solder melts.

If you want to get rid of this upper band entirely without removing sight base or cutting off barrel, the band must be filed in two—and be sure to work carefully and use a fine sharp edged fil

Fig. 193

I have before me a Ross with a perfect barrel that has been almost ruined by sheer stupidity and clumsiness—evidently a horse rasp was used to file off the band, and there are ridges nearly 1/16 inch deep filed across the barrel!

The military rear sight of the Ross is rather better than most mili-

tary sights; so if you like open sights you'll not be far wrong in leaving it on. Lyman makes a receiver sight for the Ross for eleven dollars. Figure 193 shows the military rear sight which the ingenious owner has moved back and sweated to the top of the bolt, giving the advantage of a receiver sight at no cost but a little work. It was necessary to file the under side of base to a larger radius, which the owner did by holding the sight in his hand and working on it with a half round file from the ten cent store! And it is as perfect a job of fitting as I ever saw.

If one cares enough for his Ross to make a special stock for it he will find it well worth the time and labor. Moreover, the Ross is one of the easiest of all the bolt actions to stock. The barrel and receiver are let in first; then the guard screw holes are bored; then remove the magazine from guard, and use the guard as a templet to outline its location on under side of stock. Inlet guard, then

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cut the hole for the magazine. Next mark out and cut the groove for magazine follower-arm, taking all measurements for this from the old stock. Shape up stock to desired form, with recoil pad or steel buttplate as desired. The magazine cutoff, as well as the swivel attached to trigger guard, should be removed, as both are useless.

SHORT MODEL LEE ENFIELD, Caliber .303, Mark VII. This was the service arm of the British troops in the World War, and gave an excellent account of itself at Verdun, the Somme, the Marne, and other famous battle fronts. This arm is not regularly sold in the United States, but is available through representatives of the Birmingham Small Arms Company, and quite a number of them are in use in various parts of the country, particularly in Canada. It is now the official service arm of the R. N. W. M. P., and is a most suitable arm for rough usage under all conditions of service. It makes up into an excellent hunting rifle.

The rifle illustrated on page 458 is now being remodeled for a chap who does not greatly enthuse over the Lee Enfield at all and who is particularly opposed to two-piece stocks. I therefore set about (with some misgivings I must confess) devising ways and means of consolidating the forward and after portions into one, on the time proven theory that in union there is strength. A surreptitious letter with some rough sketches addressed to the victim brought forth the glad tidings that in his opinion the thing was feasible; so, committing my spirit to its Maker I said "here goes nothin' " and let drive with the hacksaw, taking off socket at rear end of receiver, and then welded on receiver and guard tangs.

The safety which originally was attached to the side of the socket, was merely swung forward and attached alongside of receiver, being set in a little closer by filing down the washer that goes in under the spring. *It works.*

The high and unwieldy receiver bridge, whose sole purpose is to provide a way for the cartridge clip, was sawed off and ground down smooth on both sides of receiver. Front and rear military sights were stripped off, and a front sight ramp made and fitted, after a swivel band had been fitted at the proper point on barrel. Removal of the military rear sight left a hole straight through the barrel from side to side, missing the bore by a scant margin—yep!—believe it or not—that's the way the bloody thing was pinned on. But the same pin, driven back and filed off smoothly concealed the dirty work. There was another hole about 1/8 inch deep in top of barrel, to accommodate the end of a screw in the military sight. This hole was blanked out by tapping it and turning in a small screw which was then filed off flush. The proof marks and other impediments were filed from forward end of receiver and breech of barrel, the marks being very shallow so that their removal did no damage. Top of receiver and flattened portion of breech were then matted to match

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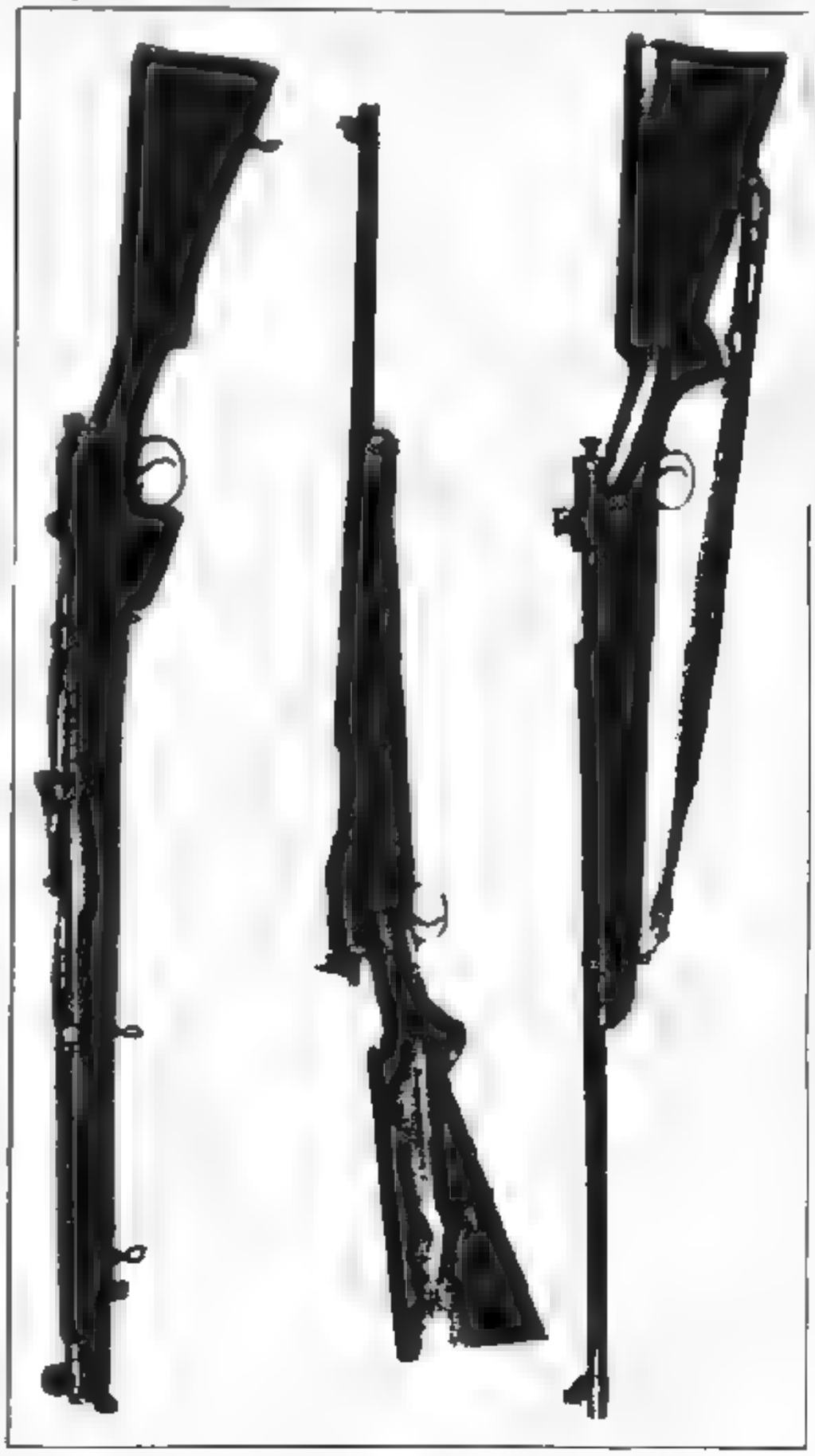
surface of front sight ramp, after which entire action and barrel were polished and blued and a Lyman No. 48 sight fitted to receiver. The barrel was left its original length—about 25 inches.

The rifle is being stocked in about the same manner as a Ross would be stocked—by letting in the barrel and action first, then the guard. The illustration shows the rifle "as is" today. The only change in the mechanism, outside of easing up the pull a bit, was the addition of a small flat spring to bear against the rear portion of the trigger to take up the rattle. Before that was done the trigger served a two-fold purpose—firing the gun, and calling the chickens.

THE 1873 MODEL SPRINGFIELD, Caliber .45-70. Here's a real he-gun! A good old punkin-slinger in its day—and its day is not over yet. The .45-70 load is still one of the best for knocking down game at comparatively short range in heavy brush and timber, and is preferred by many for this work.

With its long barrel the rifle as issued by the D. C. M. for $1.25 is a bit unwieldy for most of us. By cutting the barrel to 24 or 25 inches the handling is much improved; and the stock may also be cut down to a carbine with little work.

Figure 194 shows a special remodeling job done for Dr. Paul B. Jenkins, who is a great admirer of the '73 Springfield and the load it shoots. In this case no effort was spared to modernize the old gun as far as was humanly possible. The trigger pull was lightened as explained in Chapter 28. A piece of tool steel was welded to the upper tang to lengthen it sufficiently to provide a firm base for the rear sight. The Lyman 103 was chosen in the model supplied by the makers for the '99 model Savage, as the base of this sight fitted the rifle tang quite as well as the one it was made for. The trigger guard was cut down to about 5/8 inch in width, and the guard swivel cut off. A Lyman No. 6 folding leaf sight was attached by a band around barrel. Another band holds the forend snugly against barrel, the stock being held otherwise only by the rear tang screw. A special sight ramp was made, and fitted with a Sheard gold bead made for the Mannlicher-Schoennauer. Top of ramp and top of barrel ring of receiver were matted, and entire gun polished and re-blued. The hammer was ground away slightly at the back under the spur, and also on the lower part, and skeletonized to further lighten it. This was done by drilling a string of holes and filing away the metal between them with a rat tail file. The action was



Upper: The British Enfield, a rifle which has great possibilities for converting into a sporter, has a ten shot magazine and is an easy working, fast action. Center: A custom built sporter having bolt sleeve peep sight. Barrel and action should have been inletted deeper into the stock. Lower: The rifle that can hold its own in any company. The Springfield Sporter sold by the D. C. M. for $4.00, stock has been worked down slightly all over grip curve deepened, grip cap fitted and stock refinished

then stocked in good dark American walnut, the stock fitted with steel grip cap, horn forend tip, and a Mannlicher-Schoennauer buttplate with long trap. The shape and dimensions of this stock are not adapted to many shooters, but they suited Dr. Jenkins, who has long arms and rather large hands. Studs were attached for detachable swivels.

In stocking this rifle the receiver plug, of which the upper tang is a part, should be removed before inletting the barrel and receiver.

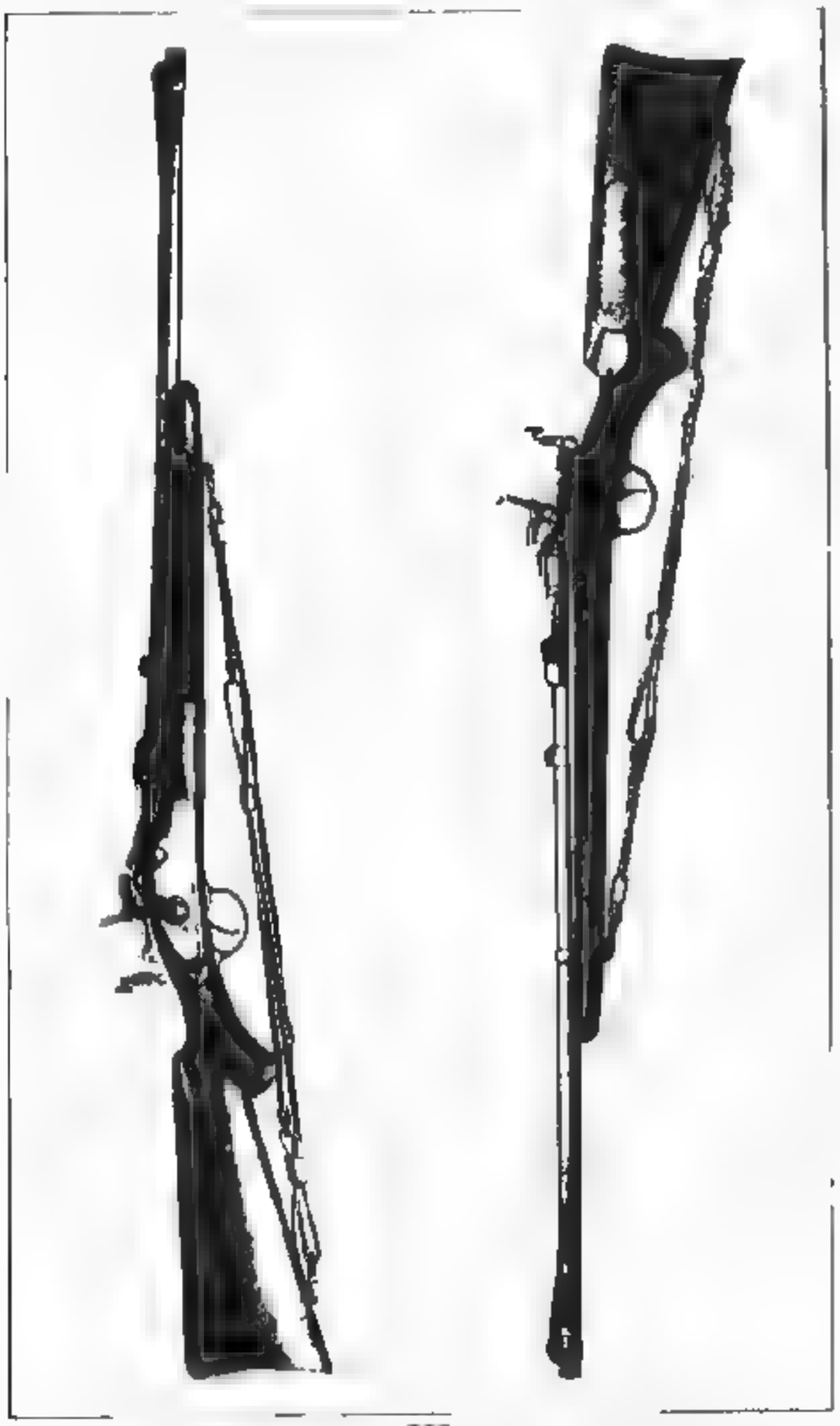


Fig. 194. Dr. Paul B Jenkins .45/70 Springfield after being modernized

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Then fit in the tang after it has been lengthened as described. The only difficulty encountered was in locating the two screw holes on the left side, for the screws holding the lock plate. These should not be drilled until the lock plate has been inletted, after which the drill may be run in through the holes in plate, from the right side. A small half-round chisel was used for countersinking these holes on left side of stock for the screw bushings.

OBSOLETE SPORTING RIFLES: One of the greatest joys of the gun-crank lies in working over and rejuvenating some old gun, perhaps picked up in a pawnshop for nearly nothing, and making it into a handsome and useful modern arm. A brief perusal of the classified ads in any outdoor magazine will show a steady demand for old Ballards, Sharps, Winchester Single Shots and perhaps others. And most of them will richly reward the experimenter. The Ballard action is just as good today as it ever was, and while some may believe there are better actions for a .22 caliber match rifle, the Ballard enthusiast cannot be convinced of the error of his ways—it's a Ballard or nothing for him. He'll have a fine barrel made and fitted, then he'll get busy on the action, tuning it up and polishing the parts, making new parts where necessary, adjusting the set triggers, and finally stocking it to the queen's taste!

The admirer of big calibers will perhaps unearth a Sharps-Borchardt action, with a barrel for some obsolete cartridge, and will either move heaven and earth to find ammunition for it, or else have a new barrel made to shoot some cartridge he can get. For several years I have been hoarding an old Borchardt action in hopes of someday getting round to having a .45-70 nickel steel barrel made, and then making a modern stock for it.

Both the Sharps-Borchardt and the Ballard have the stock held to the receiver by a long screw through the butt—in my opinion the very best way, as it permits no looseness between stock and action. The Borchardt is particularly good for modern stocking, as, having no tangs, the pistol grip may be shaped up as close to the trigger and with as full a curve as desired.

When these old actions, originally intended for black powder, are rebuilt to be used with smokeless, the firing pin hole should be bored out and bushed with tool steel, and a new firing pin of high grade alloy steel supplied. A. O. Niedner of Dowagiac, Michigan, is equipped to do this work, and understands it. As a rule these old actions are in pretty good shape, requiring few if any new parts, most of which are easily filed out by hand. Either chrome vanadium alloy steel, or a 90 point carbon steel should be used for working parts, the latter being also good for flat springs, if any must be made.

Figure 67 shows a single shot Winchester action remodeled for Colonel Townsend Whelen. This rifle is fitted with a .25-20 barrel chambered for the .25-20 repeater cartridge—always a favorite with

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the Colonel,—and a splendid little load, now that it is available with non-corrosive priming and lubaloy or copper bullet. This action was originally the straight tang model, without pistol grip. The lower tang was bent cold in the vise, 3/8 inch brass rods being bent at right angles and hung on the vise jaws, spaced as required to put the bend where desired. This bending of course threw the tang screw hole out of position; so this hole was welded up and extra metal built up on the tang to form a small shelf parallel with the upper tang, or at right angles to the tang screw. A hole was then drilled in this shelf for the screw. The screw hole in end of lower tang was also welded up, as it was necessary to cut off a little of the tip, and square the end of this tang. The tip of upper tang was also slightly shortened, to permit setting the comb as far forward as possible.

The lower tang was then filed flat across its outer surface, instead of rounded, as it was originally. The lever was straightened out by heating and bending in a vise, and a piece of cold rolled steel welded to its lower end and shaped as shown in sketch, Figure 67. Additional welding steel was flowed onto the lever at the bend just behind trigger, and the guard re-shaped as shown by grinding and filing. This gave considerably more finger room, and in effect, a longer grip. The upper side of lever knob was notched to receive the turned down end of a spring catch fitted in above the grip cap as shown. The upper side of lever was filed flat to fit smoothly against the flattened outer surface of tang.

Probably the catch at lower end of lever is not necessary, but it was specified in the order, consequently it was made. It could be omitted, as the natural tension of the action spring will keep the lever closed normally, but the extra catch is of value in preventing its being knocked open if caught against brush, etc.

A good example of a remodeled Winchester SS is shown in Figure 195.

There are a lot of old single shot Winchester actions kicking round the country, and a better action was never made, I believe. It will handle any load up to and including the .30-40, and has been used with the .30-06. When used with a heavy load, the firing pin hole should be bushed, and the Mann-Neidner firing pin fitted.

The suggestions contained herein are not intended by any means to cover the entire field of remodeling—they merely show what has been done in some instances, by way of suggesting what the amateur gunsmith may do with old rifles he has or may acquire in future.

It would not be correct to include the 1890 model Winchester in the list of obsolete arms, yet in view of later design, this splendid little arm would be considered obsolete by many cranks. Admiring the action, but not satisfied with the handling qualities, Mr. R.

Bonar, of Pine Bluff, Arkansas, has improved the handling of his 1890 Winchester at least 200 per cent by restocking as shown in Figure 197. In the letter accompanying these photographs Mr.

Fig. 196—Upper, The 1890 Winchester .22 in original boy-size factory job after being remodeled by R. Bonar Fig. 195—Lower, ■ Winchester special stock and hunting scope.

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Bonar expressed some very sensible thoughts so I present both his letter and a view of his work:

"It seems to me that in modern gun-writing, too little space is devoted to what is often termed the 'tin can rifle,' a .22 for general small bore shooting, but not in the strictest sense of the word, a true target rifle.

"Such a rifle could be any of the standard small bore repeaters of which all are at their present development excellent pieces, but their chief fault as I see it, is that they are nearly all stocked and balanced for the juvenile trade only.

"The make and type are largely matters of personal preference. In my own childish mind, I think there is no finer example of the .22 rifle design than the 1890 Winchester, though it, in all its perfection, is frowned upon by many on account of the hammer which I regard as one of its good points rather than a fault.

"But like the rest of its klan, it is cursed with the typical boys' stock and screwdriver handle action slide, so I have attempted to make more 'gun' out of it by restocking it with a pistol grip, cheek piece, and larger action slide.

"Also you will note that the lower tang was curved downward; a 'V' shaped piece of steel was fitted on top and riveted to it in order to form support for the rear end of main spring. Adjustment on main-spring was taken care of at the usual place by a screw long enough to go through the block. The upper tang was cut off one-half inch to permit carrying comb forward, and the Lyman sight base set as far forward as the movement of hammer would permit. Buttplate is one for standard Winchester 54, with a trap built in.

"The larger action slide handle did not present much of a problem, except the alignment of the holes of two diameters, which was accomplished by inletting the action slide first, then using it as a guide for continuing the hole at a smaller diameter. Teeth were filed in the end of the magazine tube and same placed in a vise to bore out wood, as no bits of the correct size are available.

There's a gun-crank after my own heart! He took a rifle of undeniably sound mechanical design and construction, but one which most people cuss because of its small stock and poor grip, and made it into a real work of art. The stock is well shaped, and the checking and finish would do credit to many a professional gunsmith. And I must say that I admire a man who will stick up for a rifle he likes when other folks have it down and are jumping on it—then go ahead and prove himself right by making something worth while out of it.

There are a lot of tin-can rifles—Remingtons, Marlins, Winchesters, Savages, Stevens, and others, that would be vastly more valuable to their owners if they would do a little head work and a little hand work on them. Why not?

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CHAPTER 31

SHOTGUN REPAIRS AND ALTERATIONS

IN the whole field of gunnery the high grade shotgun undoubtedly outranks all other classes of firearms for superiority of workmanship, and finish. A shotgun of the better sort produced by one of the recognized makers is not only a work of art, but it is also an example of the finest sort of mechanical skill. The lock and other parts are fitted up with all the precision of an expensive watch; the smallest possible tolerances are observed in the fitting of all parts, and they are well polished and finished in keeping with the outside of the gun. In the more expensive grades, the working parts of the locks are sometimes gold plated—which by the way seems a good deal like gilding the lily; for high grade steel properly fitted and polished, owes no apology to any other metal. The plating of parts, while of some value in preventing rust, certainly does not tend toward smooth, quick working.

In considering the class of workmanship and finish on such high grade guns, one would expect to see shotgun repairs and adjustment confined to the better class of workmen who specialize in this one branch of gunsmithing. Yet such is not the case. The average "jackleg" gunsmith with a hole-in-the-wall shop does perhaps a hundred shotgun to one rifle or pistol job. The shotgun is his bread and butter, just as the sale of shotgun ammunition is the mainstay of the sporting goods dealer. For practically every man and boy who ever fires a gun of any kind, owns a shotgun,—and the cheaper guns of course receive abuse which necessitates frequent repairs.

So it would seem, with all the experience he has that the average gunsmith should develop a high degree of skill in shotgun work. But he doesn't. In most cases he is a rough-and-ready sort possessed of an infinite number of rough-and-ready kinks to make a gun shoot. And he will unhesitatingly undertake to raise or lower the pattern

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of your barrel, re-stock the gun for you, or repair the mechanism, open up or increase the choke, or lengthen the chamber. He will with entire confidence tackle a job from which the factory that made the gun would shy off; and if he falls down, and ruins the gun, he'll have an air-tight alibi all ready for you. Yet chances are that he'll do a pretty fair piece of work—rough, perhaps, but effective to a degree,—and the price he charges you won't necessitate putting off the purchase of a new flivver.

The man who merely owns a gun for shooting purposes rarely pays over $50.00 for it—and the type of gunsmith just referred to will do all the repairing he requires in a way that will satisfy him. But the chap more greatly blessed with this world's goods, who takes real pride in the appearance of his guns, and who spends from $175.00 to $1,000.00 or perhaps more for them, should steer clear of this type of workman. Such a gun should in most cases be sent to its maker for repairs or adjustments—of which few will be needed, if the owner properly appreciates it, and gives it the care it should have.

There are men, however, who never learn that a gun was not intended to hold down barbed wire fences, nor to be stood up in a leaky woodshed uncleaned during a rainy night. I have in mind a man whose financial statement is such that he need never consider

the cost of a gun; and the total value of his firearms runs well up into thousands. Yet, apparently, he has no more appreciation of their beauty or quality than he has of a six dollar rabbit gun—he treats them just the same. I recall that this man once borrowed a $600.00 shotgun from a gun manufacturer, and took it out duck hunting. A day or so later he walked casually into the office and set the gun in a corner. After he had left, the manufacturer took one look at it and began to swear; then he looked closer, and swore harder and louder; then he stripped off the lock plates and dismounted the gun, and at sight of the water, sand, and whatnot contained therein, he cussed for twenty-seven minutes without once repeating himself—" held the watch on him, so I know. Besides water and filt. in the action, the checking on forend was all ground off, the stock was marred and battered, the barrels were worn along the sides and covered with streaks of green point. Investigation ultimately disclosed that his friend had lost the oars and had used the gun to scull the boat! And when confronted with evidence of his guilt, the culprit merely grinned and said "Hell, I thought you made good guns that would stand a little service!"

But getting back to gunsmiths, there are but a few in this country who have developed the skill, and who appreciate the necessity for such skill, to enable them to work on the better grade shotguns. The average American gunsmith is educated to the fact that the average American gun owner wants a gun to shoot, and that's about all; and further that he will not pay for any unnecessary work.

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All this is written by way of warning to the owner of fine guns, not to entrust them to the tender mercies of old Bill, the town locksmith, no matter how good Bill may be at wiring up a busted stock or raking out the rust from the barrels at the end of the duck season. Bill's a good man in his line, but his scope of usefulness ends with the crude, practical job on the inexpensive gun.

This is no slam at the average gunsmith. He does the work there's money in—the work the public wants—and he does it the very best he knows how. Moreover, he seldom charges even as much as the job is worth, and in a pinch his ingenuity will assert itself to the point of making by hand a missing part for some obsolete model, and will have the gun working top-hole fashion while the factory tool-maker would be figuring the cost of jigs and fixtures for the job. This kind of gunsmith is an asset to the community—just don't ask him to get out of his class.

Exacting as shotgun work of the better sort is, there are a lot of jobs that the aspiring amateur will want to do for himself—jobs which, if thoroughly understood, he will do better than most gunsmiths would do them, because time will be no object; he doesn't have to stop the work when he thinks he's done as much as he can get paid for. For be it known that the amateur gunsmith who counts his time, is going to be alarmed at the "cost" of the jobs he does for himself. The quality of the finished job, the pleasure derived from the work, and the satisfying knowledge that it is done *right*—these are the real reasons for home gunsmithing.

The gun owner can afford to completely refinish his stock after fitting a recoil pad—the gunsmith, knowing he can get only a couple of dollars for the same job, must merely patch up the finish near the butt. The owner will not object to spending his evening hours for a week smoothing up the action parts, getting the triggerpulls exactly right, etc.,—but if watching the clock as the gunsmith worked, he would most likely say "That's all right—let 'er go at that—no use putting a lot of time on that old pot-iron!" And so it goes.

The jobs which the shotgun owner of fair amateur mechanical ability can hope to accomplish satisfactorily will include: Restocking, altering the stock, or refinishing it; checking or otherwise decorating the stock; rebluing barrel and action, and hardening and hard fitting parts subject to wear. All these have been covered elsewhere in the book. But he can also, by the exercise of care and patience and a study of the needs of the job, remove dents from his barrels, make minor alterations in chamber and bore, open up a choke, cut off damaged muzzles and re-choke the barrels to a degree, solder back a loosened rib, fit sights as desired, and make and fit essential action parts in old models for which parts are no longer available.

The first—*the very first*—essential to satisfactory shotgun work

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is plenty of good screwdrivers in sizes to fit all the frame screws. Nothing so quickly spoils the appearance of any gun as gouged and battered screw heads. Screwdrivers cost little to buy, and are easy to make; and one should not hesitate to grind the point of a driver to the exact size of a particular screw slot. The tool will not be injured, but may be re-ground a number of times; and it's quite possible a new screw might cost you more than several screwdrivers.

DISMOUNTING LOCKS: To the man who has never had occasion to dismount his shotgun, the process is somewhat vague, so a bit of instruction on that point may not come amiss. First of all open the gun to cock it; then remove barrel and forend. Remove wood screws from rear end of guard and unscrew the whole guard from the frame, turning it counter-clockwise. In some guns, the guard instead of being threaded into frame, has its end shaped like a bayonet lock, to be removed by a quarter-turn; in others, the guard pushes forward or back, and unhooks. Never force anything on a shotgun—try it gently until you are sure how it works.

If the gun has side locks they may now be removed. Usually they are held by a single screw set in near the rear end and extending through both plates. Remember that nearly all the wood is cut away in a side-lock gun, so be careful not to chip off the edges of stock around the locks. Insert a small brass rod having its tip end bent into a short hook through the screw hole, and lift up on this while tapping the stock very lightly around the plate. The plates will now move backward a trifle, releasing their front ends from the action body. Next remove the trigger bar, by taking out the wood screws at its rear, and the large screw which goes in from the top under the top lever. Hold the lever to one side while removing this screw, which usually is set in very tight. It is best to have the stock clamped firmly in the vise while dismounting the action. Also remove the tang screw, and the screw holding the plate on bottom of action body. Lift out trigger plate with triggers attached, and stock can be removed from action.

If dismounting a box-l- gun, after the trigger plate is removed it is necessary to remove the sears before the action will come free from the stock. Usually the sear pin can be pushed out with a drift punch; sometimes a light tap is necessary. Keep the thumb over the sears to prevent the springs from jumping out. Lift out sears and springs, and action will come off stock.

When the bottom plate of action is removed, look for screws and other loose parts, such as the lever-lock and its spring. Lift these out before you thoughtlessly turn the action over and lose them.

Side locks should always be removed and replaced with tumblers or hammers cocked. With box-locks the hammers must be down, i. e., not cocked.

Inspect all working parts carefully for breaks, rust, etc. If the

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action is gummy or rusty, place the parts to soak in a pan of gasoline with a little thin cylinder oil added. If necessary scrub them with a stiff brush, and dry carefully. Scour off any rust on a sheet of fine emery cloth, using care not to reduce the size of any bearing surfaces, and polish with crocus cloth. Take triggers and spring from trigger plate and clean them up also. Now check all parts for damage. Note the sear points. Sometimes they become nicked or broken off at the corner, giving a mean, draggy pull. If the damage is slight it may be carefully ground out on an oil stone, but if great it is best to secure a new sear, as shortening it very much will also shorten the fall of tumbler or hammer, possibly causing misfires. To fit a new sear, set it beside the old one, and push the sear-pin through the hole in both sears, then set them together in vise with edges together all round. File and stone the new one to the exact outline of the old one, leaving the point which engages hammer or tumbler notch just a trifle longer on the new one. Then assemble the new sear in action and try it, working down the point as required on an oilstone. (See Chapter 28 for adjusting trigger pulls.)

Weak MAINSPRINGS are sometimes found which give very slow lock time and occasional misfires. As a rule the remedy is a thicker mainspring; sometimes, however, old springs may be improved by re-forming and tempering. Never try to change the shape of a spring while cold. Cut a piece of thin steel a shade thicker than the crotch of the spring; heat spring to dull cherry red and

drive this between the ends, forcing them further apart. The curve in the longer limb of spring may also be straightened a trifle. Then the spring must be rehardened and tempered. See Chapter 21.

Possibly the only fault in the spring lay in the temper—and this treatment may make it quick and snappy. On the other hand, the steel may be of poor quality, or your tempering may not turn out well, in which case get a new spring. Buy the spring from the factory where the gun was made if possible. If obsolete, a spring may be obtained from Schoverling, Daly and Gales, New York City, or from Gus Habich, Indianapolis, Indiana, or elsewhere. Firms handling miscellaneous parts for old guns usually catalog them with full size illustrations which make selection easy. If you can't find exactly the right size, buy one a little larger, and dress it down by filing. Leave both limbs a trifle thick after fitting ends of spring so it will go into the action, then try it and dress it down slowly until the action suits you. The middle portion of spring where it is bent should be the thickest point, with a gradual taper toward the ends. Filing a thin place in the middle of one limb will weaken and ruin any spring. After fitting a new spring, assume that the maker tempered it properly until you have proved otherwise. Usually springs bought from a reliable firm are properly tempered and not to be improved by efforts at retempering.

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Weakened or broken coil springs should be replaced with factory springs if possible, or new springs made in the lathe, from piano wire. If a lathe is not available, very satisfactory coil springs may be made by winding by hand around a steel rod. Flatten the rod slightly at one end, and clamp this end, with end of piano wire, in the vise. Draw the wire tightly in both hands and wind the coils with as even spacing as possible. Due to expansion of the spring after winding, the rod used must be considerably smaller than the spring desired, and the exact size for the winding rod can be determined only by experiment. Wind on a coil or two, note the expansion, and if too much, start again with a smaller rod.

Piano wire springs wound in this manner need no tempering, particularly if of small size. For larger springs that must be wound by hand, it is often better to anneal the wire carefully in a gas flame, when it will wind readily with minimum expansion. Then harden and temper in oil.

PINS: Sometimes a pin used to hold parts in action body will be damaged in removal; or it may be too loose in its hole, making a new and tighter pin desirable. Pins should be made of drill rod. To ascertain the size stock required, try the old pin in a drill and wire gauge, just as you would try a drill for size. The gauge shows the number of drill rod needed, also its diameter in thousandths of an inch. If the old pin is too loose, order a piece of rod three to six thousandths, or say, one size larger on the gauge. Cut a piece of rod to length needed for pin, round the ends with a fine file, and polish them smooth. Harden at cherry red in oil, then draw to straw color in water. Then if too large for the hole, polish to size with fine emery and crocus cloth. If a pin is lost and it is desired to get the size for making a new one, select a drill the shank of which just enters the hole. The number of drill is usually marked, or its size can be ascertained with the drill gauge. In a pinch, you can cut off the shank of the drill and make pin from it—may be better than waiting for a new pin or piece of stock if the ducks are flying.

DAMAGED SCREWS usually mean damaged screw holes also—but not always. If a screw like the old one cannot be found, ream the hole slightly and tap for a size larger screw—and use a standard machine screw size, so it can be replaced if lost or broken again. Always case-harden the screw in cyanide when it is all fitted and head dressed down to shape,—about one or two dips being sufficient. Surface hardness only is required in screws—too deep hardening, especially in small screws, will make them break easily.

Often the wood screws used in tang, etc., will have their heads badly marred. And as the heads of such screws are often "engraved" the owner may despair of obtaining others to match. But inspection will show that the "engraving" usually is nothing but a few short file cuts made at different angles radiating from the center. Take

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an ordinary wood screw of the proper diameter. Cut the point off blunt like the old screw. Turn it in snug, and dress the head down flush, then decorate as desired. Case-harden slightly, and quench in linseed oil, which will darken the color to match the tang.

If screws turn into the holes too easily, and will not tighten showing that the threads in the wood are damaged, ream out the hole lightly with a taper pin reamer; whittle walnut plug to fit snugly in the hole. Put a few drops of du Pont Cement in the hole, also coat the plug, and drive in. *Take care not to make the plug with too sudden a taper, so that driving it in splits the stock.* Cut off projecting end of plug with a sharp chisel, center and drill new screw hole in plug, and turn in screw. Do this immediately before cement dries, as the screw will then force the plug tightly against sides of old hole, reducing danger of splitting.

Occasionally BROKEN PARTS in old guns can be repaired by welding. Some smiths will braze them,—a practice which should never be followed. Brazed parts are almost certain to spring out of shape slightly in use, and the soft metal in the joint promotes excessive friction with other parts. When parts are properly welded by an acetylene welder who knows his business, they may be almost as good as new parts. The break should have its edges scarfed open by filing leaving a gap at least 1/8 inch wide on both sides, the broken edges touching only in the center. (See Chapter 23.) If necessary to send them away for welding, get a lump of fireclay, and holding the broken parts carefully in position, press them into the clay to give a full impression. Turn them over, and take a similar impression of the other side. Dry the clay slowly in the shade, and send this mold along with the broken parts to the welder, who can lay the parts in exact position in this mold, so that after welding, you can shape them up with a minimum of work.

Always specify acetylene welding for the repair of broken parts. Electric welding is excellent for some things, but not for this kind of work. The acetylene torch heats the broken parts themselves to welding heat, and the welding metal mixes with it to form one homogeneous mass. In electric welding the work itself is not fully melted, hence the joint is not so strong. Moreover, it is necessary to leave on some of the excess metal after an electric weld, while with a torch weld it can be dressed off flush and smooth, and the entire part case-hardened if necessary.

Broken hammers should be replaced by new ones, although in some cases they may be successfully welded. Various size hammers in the rough may be had from either of the firms already mentioned, and they can be fitted with a minimum of filing, after which they should be polished, hardened, and very carefully tempered. Draw the temper from the lower end toward the hammer nose, which should be blue, shading off into dark blue toward bottom end. Better to have the hammer a trifle soft than too brittle. If a hammer can-

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not be obtained, the ingenious workman will file one out of a piece of good tool steel, fitting, hardening and tempering it to suit. Both the hardening and tempering should be done in oil, to give added toughness. The inside hammers, or "tumblers" of hammerless guns may usually be secured from the factory where the gun was made, or they too may be filed out by the careful workman far from a base of supply. They too must be carefully hardened and tempered, and if able to control the colors, temper the percussion end, or nose, at blue, and the sear notch at straw yellow. This assures sufficient hardness to prevent wear changing the pull, with the nose soft enough to prevent breaking.

Some guns have the FIRING PINS made in one piece with the hammers—and sometimes they break off. The better plan of course is to secure or make a complete new part. Sometimes, however, it is practicable to dress off the face of the hammer where the point of firing pin broke off, and attach a new pin. A standard taper pin reamer should be used to ream out the hole drilled in the hammer nose, and the shank of new firing pin turned to a tight drive fit in this hole. It should have a shoulder which bears on the surface of hammer nose, to take up the force of the blow. After the pin is driven in tightly, with full bearing against this shoulder, drill a small hole through hammer from side to side, biting half its diameter into the side of the firing pin shank; drive a pin tightly into this hole.

It would seem logical to first turn the point of the new firing pin to shape and size in the lathe—but due to the difficulty—almost an impossibility,—of locating it exactly in the hammer nose, it is best to leave the firing pin point full and thick, then after it is attached to hammer, it may be shaped up by careful filing to match

its mate—the other hammer. Finish fitting by coating pin lightly with Prussian blue, and trying it in the gun, noting where the blue is rubbed off by friction against the side of firing pin hole in action body.

Separate firing pins on both hammer and hammerless guns are often broken by snapping the gun on empty chambers. New firing pins can easily be turned up to size and shape from drill rod, or even filed out, if you have no lathe. Choose a piece of rod the same size as the largest diameter of the old pin, using the drill gauge to get the size. After the pin is shaped up and fitted it should be hardened in oil at cherry red (use care not to heat the point hotter than body of pin) then draw the temper to blue.

The proper shaping and tempering of firing pins is very important and the instructions given in Chapter 24, pages 372 and 373, should be read over and carefully followed.

A LOOSE FOREND is a constant source of trouble, particularly in the cheaper guns. These may often be tightened permanently by careful work, or a new forend iron may be secured and fitted.

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Schoverling, Daly and Gales carry forend irons of various types fitted into walnut blanks. The old forend complete should be sent as a sample when ordering the new one.

Cheaper guns usually have the "snap-on" type of forend, in which a curved spring steel lever about an inch long is pivoted into the forend iron at one end, the other end bearing against the end of lug on barrel. Such forends can often be tightened as follows:

Remove the spring lever, and with a sharp pencil carefully outline its shape on a piece of paper. Heat to a low red and straighten it out. Then "cold forge" it by hammering until it is stretched out about 1/16 inch. Heat and bring it back to its original curve—it must be exactly the same shape as before, only longer. Now carefully harden it in oil at cherry red, and flash off the oil twice to draw the temper. Replace it in forend and try it for fit. Carefully and slowly file down the point until forend will just snap back into place with stiff pressure. Examine the spring to be sure the pressure has not bent it—if so, the metal is defective, or the temper is drawn too much. Rehardening and tempering will correct the fault in the latter instance, or a new piece may be filed out of good steel and properly tempered.

Sometimes the inside sliding catch in the forend will be worn, causing the looseness. Remove the catch, heat and forge it to draw it out, re-shape by careful filing, harden, and draw temper to straw yellow. If this does not cure the looseness make a new catch of tool steel.

Forend looseness may be caused in some instances by wear on the barrel lug. Try laying this lug on a block of steel and hammering lightly on both sides—often this will stretch it sufficiently to give a tight fit. It should then be smoothed and shaped up with a fine file.

If necessary to fit a new forend iron, you have a job on hand—not an impossible one by any means, but one requiring the most careful filing and fitting. The circular hinge at rear of forend iron must first be fitted to conform with the shape of hinge joint at front of action body. Coat the hinge joint with Prussian blue and spot the parts into perfect contact. For this purpose the best files are known as "warding files." One side has a rather full curve, the other being more nearly flat, but slightly curved also. An American Swiss warding file No. 1 cut, 8 inch length to start with, and a similar file with No. 4 cut for finishing, will do the job nicely. Be careful to avoid rounding off the corners on inside of this curve. Bring them up sharp and true, maintaining contact at all points.

Now coat the center strap of forend iron near the lug slot with blue, and carefully fit it to the lug. The blue will show where the lug refuses to enter. This fit must be very tight and close. Use small, very fine cut pillar files for this fitting, also to smooth up the lug.

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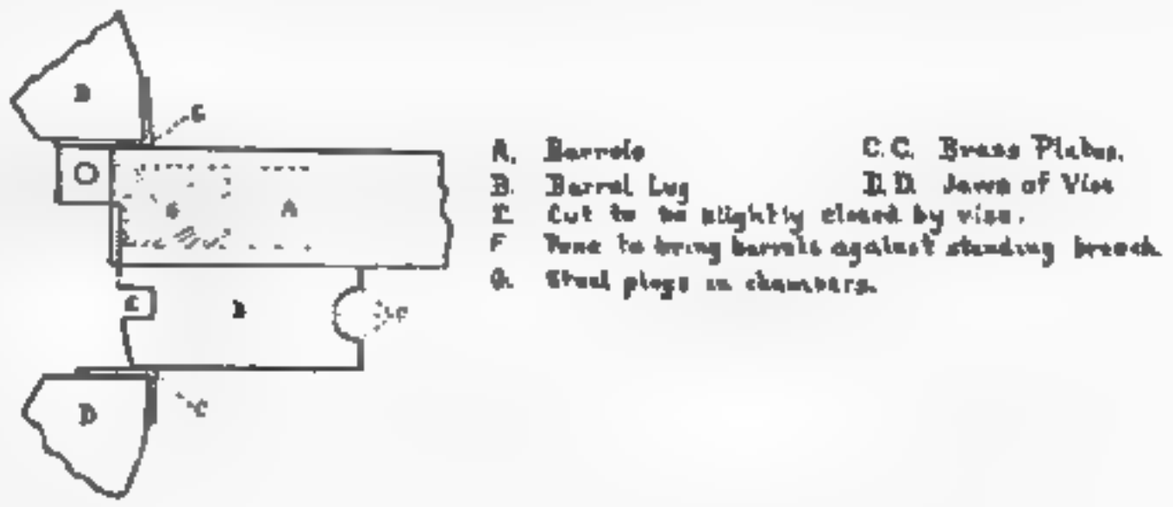
LOOSE ACTIONS: The hinge joint of a good shotgun seldom comes loose, despite the fact that the barrel lump is not hardened. This does happen on cheaper guns, however, and can be remedied by taking a hammer and peening lightly the lug or lump near the semi-circular cut in its forward end—the cut which fits against the hinge pin in action body. Do not hammer too close to the edge of this cut—the idea is to draw out the lug slightly rather than battering edges of cut. The lug should rest firmly on a block of steel while peening. When you have a good tight fit, smooth off the sides with a fine cut pillar file.

When barrels do not fit the action body tightly at bottom, first try dressing off, *very slightly*, the underside of barrel lug at rear. Coat bottom of lug and also its rear end with Prussian blue, and try it for fit—sometimes a slight unevenness in the cut in action body will prevent it closing tightly. If this frees up the fit so the barrels can be pushed down, but will rise slightly when released, the fault is with the lower locking lug. Try peening around the notch in rear



of barrel lug, and if this fails to get results, use the method illustrated in sketch above. First turn up a couple of steel plugs to a tight push fit (but not a driving fit) in the chambers. These are to prevent mashing the barrels out of round. Now set the barrels in vise as shown, with jaws protected by sheet brass, and set the vise up carefully, a little at a time, until the notch in lug is sprung upward sufficiently to give a tight fit.

The danger of this method lies in the possibility of springing the extension rib where it is let back into the standing breech. If this occurs on a gun having a cross bolt, the bolt will not fit through the rib. To prevent this happening, an extra piece of brass may be inserted over breech, just forward of rib extension, to remove pressure at this point.

Another method followed by many gunsmiths is to remove the hinge pin in the front of the frame, and fit a larger pin, then file out the semi-circular notch in the barrel lug to fit it closely. I can see

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nothing in favor of this method except in the hands of an expert, due particularly to the danger of the new pin being made of material lacking in strength. A good deal of the strength of the entire breech action depends on this pin, and if it should by any chance break or shear off, the bloomin' gun would shed its barrels, and things would likely happen to the shooter. Nevertheless a lot of gunsmiths go blithely ahead with the job, making the new pin of drill rod or what have you, and apparently get away with it.

The removal of the old pin is sometimes a tough job. Usually it has been driven and shrunk into the frame and must be drilled out. Likely it is very hard.

Locate and accurately punch center on both ends of old pin. Set a high speed drill in the lathe chuck. Set the tailstock of lathe up close to chuck, with the dead center in tailstock set in punch-mark on one end of the hinge pin. Set the drill point in the punch mark on other end, and drill through the pin, pressure being provided by means of the hand feed on tailstock. The drill should be about 1/16 inch smaller than the old pin. Then ream out the balance of pin very carefully, so as to enlarge the original hole as little as possible.

Chrome-vanadium steel should be used for the new pin, although some gunsmiths use ordinary carbon steel, which really lacks the strength needed. Turn the pin to about .001 larger than the hole after it has been smoothly reamed, which reaming should have made it from .005 to .010 larger than it was originally. Taper the pin slightly so that it will start in the hole.

File a block of steel so that it will just slide tightly into the slot in front of frame, and drill through it a hole somewhat larger than the pin, cutting out the metal so as to form a U notch. Put the new pin into ice cold water, and heat up the frame until it is almost beginning to change color—this to expand the holes as much as possible. Be sure the piece of steel is in place in the slot to prevent the edges from springing together. Quickly wipe the pin dry and

drive it clear through the frame so that it projects on each side. When cool grind off the projecting ends and file smooth, then polish entire frame, and re-finish if desired.

Now fit in the hinge lug on barrel by carefully dressing out the notch as required with a straight round file, using Prussian blue or copper sulphate to "spot" it in as described elsewhere.

When the barrels lock down tightly against action body—perhaps a bit too tightly—their under surfaces and the upper side of action body should be polished to a perfect fit (See hard fitting instructions, Chapter 25).

Broken or DAMAGED EJECTORS should always be replaced by new factory parts, as elaborate machine shop equipment would be required to make them. The repair and adjustment, timing, etc., of automatic ejectors is a job for the expert, and should never be

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attempted by the amateur, nor by many of the average run of gunsmiths. A gun with ejectors is worth sending to the factory in case of ejector trouble—and the same applies to single triggers. Parts such as these are very delicately constructed and adjusted, and only those who make a business of this class of work are competent to handle it. The same goes for such gadgets and rinctums as firing pin indicators, etc.,—let the fellow who started the trouble in the first place figure out the answer.

SHOTGUN BARREL ALTERATIONS: The commonest, and also the simplest barrel alteration is the cutting off of the muzzle—sometimes necessitated by splitting, bulging, or ringing the barrels at muzzle by firing with some obstruction in bore. When the gun owner contemplates cutting off the muzzle he must remember that this is sure to remove most, if not all of the choke. Nevertheless, barrels without choke are better than no barrels at all, and if a muzzle becomes damaged the barrel is worthless until cut off.

Measure the required distance from the muzzle and mark the barrels at several points. Then bend a thin strip of sheet brass or spring steel around, so that the edge touches all the marks, and scribe a line clear round. Hold the barrels in a vise with padded jaws, and saw barrels just outside the mark with a very fine toothed hacksaw blade. Use a small adjustable head square and file off barrels with a wide, fine-toothed pillar file until square all around. (The adjustable head square being set to allow for the slight taper of barrels.) After filing polish off muzzle with an oilstone, then with crocus cloth wrapped round the stone. Round off outer edges very slightly with file and stone, and remove burr from inside with a countersink reamer twirled in the fingers, taking the lightest possible cut.

This leaves the space between the upper and lower ribs open, and this is to be filled with solder. It is better to fit the front sight before doing this, as it is much easier to tap the hole in rib if the space below it is open. Use the old sight from the cut-off muzzle, or use the Marble or Lyman shotgun sight, or make a special sight if preferred. Measure the exact center of rib with dividers, and take care to drill the hole vertically. Tap, and turn in the sight. Then take a small wad of cotton waste and pack it tightly into the space between the ribs, about one inch from muzzle. Apply chloride of zinc into the hole, and pour out the excess liquid. Then holding barrels muzzle up in vise, pour in melted solder until full, then dress off smooth and even.

Fitting shotgun sights is usually a simple matter, full instructions accompanying the sights. The thing to watch is getting the hole drilled exactly in center of rib. Some sights screw in, while others are tapered, to be driven in friction tight. Use only the reamer supplied by the sight maker, which will be exactly the right size.

RE-CHOKING: Having shortened the barrels, thereby re-

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moving the choke, our next wish is to re-choke the gun. This is sometimes possible, particularly in guns originally bored rather close, and really amounts to enlarging or over-boring the barrel back of muzzle. There are several methods of doing this, but the following is, I believe, as good as any, and within reach of the amateur or small shop.

Secure a Tomlinson shotgun cleaner of the proper gauge for the barrels. Thread a steel rod to fit the screw end of cleaner. Remove the brass wire gauze from wood strips of cleaner, and cover their round sides with rubber cement. Cut pieces of No. 1/2 Carborundum cloth to fit, and coat back of cloth with rubber cement. When cement is nearly dry, press the cloth onto the wood strips, when it will stick firmly, then fit sticks back into cleaner. On the steel shank, about two inches from the Tomlinson cleaner, paint a bright colored ring or stripe. Now chuck the other end of this rod in a high speed breast drill, insert the cleaner into the muzzle until the painted ring on shank is even with muzzle. Now turn the drill rapidly, thus polishing out and enlarging the bore at a point from the muzzle the distance the painted ring is from the cleaner. When the carborundum cloth is worn out, peel it off the wood strips and replace with new cloth. Measure the bore frequently with inside calipers, carefully transferring the diameter to the micrometer, and comparing the reading with the measurement before you started polishing.

The rounded ends of the wood strips on cleaner will taper off the choke thus formed, preventing a sharp shoulder. When the measure is two or three thousandths larger back where you are polishing than at the muzzle, stop the work, and substitute a long shank with which you can reach through the barrels from the breech. Fit the cleaner with new abrasive cloth to this shank, insert it from the breech until it is in the same spot where the first polishing was done (not reaching clear to muzzle). Fasten a small clamp or stop collar of some kind on rod to prevent it going in further. Now fasten rear end in drill chuck and polish out the entire length of bore, from front of cone to choke. The idea is to gradually enlarge the rest of bore back of the choke, bringing the sides to straight lines. You can tell when they are straight, and without humps, by holding barrel to the light with a straightedge set vertically in front of them, and noticing the line of shadow in bore—the same as when checking the straightness of a rifle barrel. When the enlarging is as straight as you can get it by drawing the revolving polisher back and forth, stop the work and you are ready for the draw polishing.

Take a long steel rod with a comfortable handle (a cleaning rod will do), and turn up a hardwood head to fit it. This head should be about three inches long, slightly tapered at both ends, and about 1/32 inch smaller in diameter than the inside of barrel

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back of the newly formed choke. Cement a piece of No. 1/2 carborundum cloth to its surface, letting the edges meet without lapping. Use this like a cleaning rod, drawing it back and forth the length of the barrel, but not touching the cone or forward end of chamber. Push it forward until stopped by the "shoulder" of the choke, so as to taper it off gradually toward muzzle. This draw polishing should be continued until all humps and uneven places are worked out of the barrels to the point where the choke begins. If you fear you are enlarging the bore too much, it will pay to stop at intervals and make a sulphur cast and measure it. When you think you have it right, make a cast of the new choke and measure it carefully. The taper should be at least 1 inch long, and the largest part of choke should not be more than two to five thousandths larger than muzzle—but hold it a little smaller for the present, to allow for next polishing.

This is done with the wood cylinder in the same manner as before, only use No. 0 carborundum cloth. Follow this with No. 00, and when it is well worn, oil it and keep on using it. When the bore is as smooth as you can get it with this, use 000 emery cloth, well oiled, then follow with crocus cloth used dry. Before cementing the crocus cloth to the polishing cylinder the latter should be padded with a layer of soft thin paper to assure good springy contact. Carry the polishing well up into the choke. Finally polish out the muzzle in the same manner with a slightly smaller plug used on a short handle.

There is but one test for correct choke in a shotgun—and that is the pattern. And it is impossible to give instructions for further polishing to improve pattern. I have always maintained that a good shotgun barrel man had a sort of sixth sense that told him what to do to improve patterns. If the pattern is ragged and patchy, it may be that the choke tapers too suddenly. Carrying it forward a bit may help, and it may not. Any changes made from this point on must be done with very fine abrasive, and the gun patterned frequently as a check on the work. Use the load you expect to do most of your shooting with—and remember that a different load may give a greatly improved pattern in the same barrel. If the bore is enlarged too much back of choke, this may cause crowding

of the shot charge, and deformation of the pellets—in which case polishing out the muzzle ahead of choke should help.

The method of polishing out and enlarging barrels by using a breast or hand drill is not easy. The work is hard and takes time. I give this method first because I am writing primarily for the chap with limited tool equipment. The man with a machine shop to fall back on will set his barrel up in an improvised rest in a lathe, mounting the polishing rod in the headstock, and do the work easier and quicker, but not necessarily any better. Or, another may attach the polishing rod to the end of an emery grinder shaft, using a piece

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of heavy rubber tubing to make a universal joint, and hold the barrel in his hands, greatly reducing the time and work of polishing.

BORE POLISHING: When satisfied with the pattern, or when satisfied that it cannot be improved by further labor, the inside of barrels should be very highly polished. Take the Tomlinson cleaner and cover the wood strips with thin sheet lead. Coat this with B.S.A. Cunirid, and swab vigorously back and forth. A half hour or so of this treatment will do no harm. Now remove the sheet lead, and cover the strips with thick cloth or felt which is first oiled, then coated with rouge or Tripoli, and the bore again swabbed full length. You can't do too much of this polishing—two or three hours of it won't hurt anything but your back!

This bore-polishing with abrasive cloth may be used for other things than enlarging the bore. Sometimes one will pick up an old gun on which the barrels seem hopelessly rusted and pitted—often the pits are not as deep as they look, and an hour or so of polishing will do wonders. In this instance the Tomlinson cleaner may be run clear through the barrels from breech to the muzzle, slightly enlarging the entire bore without changing shape of choke materially. Some alteration is bound to occur, of course, and the gun should be patterned several times before the final polishing.

After using the rouge, a final rubbing out for as long as you care to, with rotten stone and oil on the felt, will further improve the polish. Be especially careful to leave no cross scratches from the first cutting around the taper of the choke, or the gun is sure to lead badly. The brightly polished bore will not lead.

ENLARGING THE CHOKE: When a barrel throws too close a pattern, the thing to do is take out part of the choke. This is best done by reaming, and while a fine toothed spiral fluted reamer is best, I have had very good results with a six-bladed expansion reamer. Carefully used, I believe it is as good as any. The reamer should be straight, without any taper except that it should be relieved for about half an inch at end of blades. About six inches from muzzle, plug the barrel with waste. Set the reamer so it will just slip into muzzle past the taper of blades, then move the adjusting nuts about 1/8 of a turn. Measure bore at muzzle with calipers, and transfer the reading to the micrometer, and note it on paper. Hold the reamer in a large tap wrench or other suitable handle so it can be turned with both hands. Lubricate it freely, and turn slowly and carefully to avoid its twisting or chattering. It is important that the reamer be very accurately ground, and it is best to keep special reamers for barrel work only.

The following is a very good LUBRICATING MIXTURE FOR BARREL REAMING: Dissolve one pound hard white soap in a little water over a slow fire. Let come to a boil and add slowly 1/2 pint lard oil; add, while boiling enough strong soda water to make it the consistency of cream. Keep this in a bottle

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and shake before using. Use the mixture freely for all barrel reaming operations.

After the first reaming cut in muzzle, again measure the bore. From one to three thousandths will usually make a big difference. Now polish off the taper of choke as before described, so that there will be no sharp angle between the straight section and beginning of choke. Test the gun by patterning. A second or even a third reamer cut may be necessary, but usually one cut, with subsequent polishing, is sufficient.

Chamber reaming should never be attempted by the amateur, nor by most gunsmiths unless they are experienced barrel makers. If not satisfied that your gun is chambered correctly, take a sulphur cast of chamber and cone, and measure it up. In bore polishing it is important that the cone is not altered, and the polishing should end at or very near the front end of cone.

The following are average diameters of standard shotgun bores, although makers will vary slightly from these. This average measurement should not be enlarged at the point just ahead of cone even though balance of bore may be enlarged somewhat in polishing:

4 gauge	.935 inch	16 gauge	.662 inch
8 gauge	.835 inch	20 gauge .. .	.615 inch
10 gauge	.775 inch	28 gauge	.550 inch
12 gauge	.729 inch	410 gauge .. .	.410 inch

REMOVING DENTS FROM BARRELS: The man who persistently drops his gun, slams it around in an automobile, bangs it against fences, and uses it to beat his dogs is going to have dents in his barrels. There's no excuse for barrel dents, but sometimes they happen just the same. Most gunsmiths carry on hand a number of steel plugs for removing dents. Usually they do not fit very well in the particular barrel he is working on, and some makeshift method is resorted to. In most cases a plug should be turned up to the

exact size of the bore, which size is ascertained with a sulphur cast taken just back of the dent. The plug should be tapered slightly at both ends as shown in above sketch and should be polished smooth and hardened. This plug may be made of steel drill rod, or it may be of machinery steel, and case-hardened in cyanide. Measure on outside of barrel the distance of dent from the end, deduct half the length of plug from this measurement, and mark the distance

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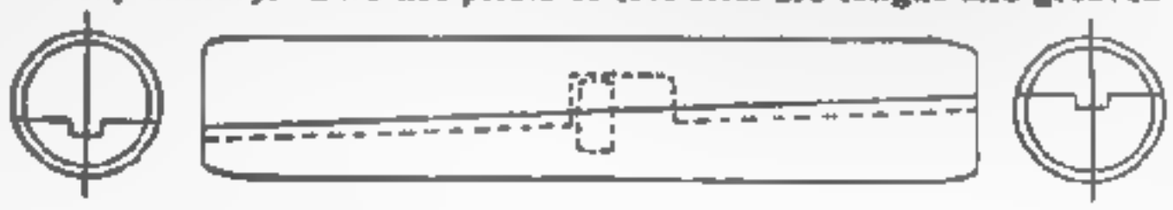
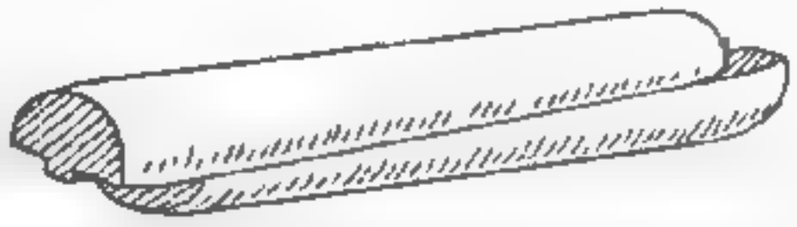
on a heavy steel rod nearly as large as the bore. Insert plug from breech and drive it into the barrel up to the mark on the rod, partially removing the dent and wedging the plug tightly in bore. Now hammer the barrel over the dent with a lead hammer until dent is entirely smooth and plug may be pushed out. It may be necessary to use a copper or brass hammer—if so be careful so as not to mar the barrel.

The best dent removers I ever saw were in the hands of an old gunsmith who must have designed them himself, as I have never seen any others. About three of these graduated in size by .005 inch for each gauge, would set a man right up in business when it came to removing dents. The drawing that is shown below is almost self explanatory. Two flat pieces of tool steel are tongue-and-grooved





on planer or shaper, and the tongue-and-groove surfaces sweat-soldered together. They are then placed in the lathe with ends 3/32 inch off center above and below the surface, and turned into a plug to fit the barrel, with ends relieved as shown. They are then heated until they come apart, and the solder cleaned off, and surfaces well polished. To use, they are placed in the barrel as shown in the isometric drawing, so as to just clear the dent. A heavy rod is held against one end, and another driven against the other end, wedging the two together like a printer's quoins, and pushing out the dent; then a little light hammering over outside of dent will loosen them and let them drop out of barrel. A hardened steel stop pin should be fitted as shown by dotted lines to prevent excessive wedging which might bulge or crack the barrel.

Two or three of these "barrel quoins" for 12, 15, and 20 gauge barrels, hardened, ground and lapped to size, and well polished,

would be worth their cost to any gunsmith doing very much shotgun work, because removing dents in barrels is one of the commonest of the small jobs—and these gadgets would do it at a profit.

SOLDERING SHOTGUN BARRELS AND RIBS. The method of joining shotgun barrels together and of attaching the ribs, which is followed by leading manufacturers of double guns, and by

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experienced gunsmiths also, may prove of interest even though the average amateur gunsmith may never be called upon to re-solder a loose rib. Here's the way they do it up at "Ithicky," most other factories employing substantially the same method:

The barrels, or "tubes" are first cleaned, then dipped into melted tin so as to completely coat each barrel all over, barrels being closed at both ends with wooden plugs. Next, both upper and lower ribs are dipped in tin and completely coated also. The two barrels and ribs are then placed in a form which holds them temporarily in their correct position with respect to each other, and wrappings of soft iron wire—about eight or ten strands to each wrapping,—are put on at intervals of four or five inches, the entire length of barrels. The wire is laid on evenly, with no strands crossing, and ends twisted tightly together on top. Long, narrow iron wedges, which are made from 16d wrought iron nails, are then driven under the wire bindings, forcing the ribs into contact with the barrels their entire length. The barrels are then set on a rack over a long gas burner which heats them all over until the solder is melted. Powdered rosin is sifted along the line where the ribs join the barrels, and a thin ribbon of solder is drawn along the joint, the heat from the barrels melting it instantly, so that it flows in completely sealing the joint. When cool, the solder is struck or draw-filed from the outside, and the barrels are ready to polish and blue.

TO RE-SOLDER A LOOSE RIB on a barrel that has been in use, the wire windings are laid on and wedges driven under them at the place where rib is loose, in the same manner as new barrels are prepared for soldering. A steel or iron rod large enough to almost fill the bore (two rods are used in the case of a double gun) are heated to dull red on the ends and inserted into the barrels, so that the heated ends come even with the loose place in the rib. Small pieces of solder, mixed with powdered rosin, are placed along the edge of the rib, and the heated rods moved back and forth until the solder melts and flows in—and the job is done. The rods are kept moving so that the barrels may not become hot enough in any one spot to mar the finish. In many cases it is impossible to re-solder a partly loosened rib without mussing up the outside finish so that reblu.ing or rebrowning is necessary; but if the rib is separated for only a few inches, it is possible to do a good job and leave no trace.

In another plant this wiring and soldering of barrels is done when the barrels are "first bored" with about a 1/2 inch hole. The tubes are placed together on rods which are pointed and accurately set on centers, to properly align them. Then, after they are soldered, any differences in alignment which develop are compensated in the final boring, reaming, and polishing operations.

RAISING AND LOWERING SHOTGUN PATTERNS. We hear a lot said now and then on this subject, which to most shooters is a deep, dark mystery—gunsmiths having done what they

could to keep it that way. Every time a trapshooter misses a bluerock he thinks he should have his pattern raised or lowered—at any rate, some of them do. The method employed at the Ithaca factory to raise a pattern is the very common-sense one of lowering the rib at muzzle and incidentally the front sight—the same principle as lowering the front sight of a rifle. This is done by loosening the rib and cutting it slightly narrower, so that it will set lower between the barrels, then re-soldering it. The height, of course, is not changed at the breech.

Many gunsmiths who lack the equipment found in large factories, have two other methods; one is to scrape out a little metal from the top of bore, really making it slightly oval. If this doesn't really raise the entire pattern it at least permits part of the charge to fly higher, though not improving the density of the pattern one bit. A reamer fitting the muzzle closely and having the cutting edges rounded and polished on one side so they will not take hold is needed here. If carefully done by one who knows, it is very satisfactory.

The other way is to bend the barrels up a trifle some six or eight inches back of the muzzle. Great care is necessary, of course, to prevent denting or "kinking" the barrels. One way is to plug them tightly after filling them with very fine sand; another is to cast a long lead slug in the barrel at the point where it is to be bent. The bending is usually done by the time-honored method used for straightening barrels—by laying the barrel across two blocks of lead and striking it with a lead hammer. The real trick lies in knowing just how hard a blow to strike to produce the desired result—and that is knowledge which comes only with long experience. To lower a pattern, a reversal of either of the above methods is indicated.

There is still another method which I have seen practiced, and I believe this is the first time it has ever been published. I strongly recommend it as being easy on the gun, and easy on the gunsmith.

The gunsmith receives the gun from its owner with a knowing air; squints through the barrels; pricks up his ears as if suddenly discovering something of a startling nature, and holds it to the light for closer inspection, the while murmuring "Um-m-mm—yeah," or something equally enlightening. Then he disappears with it into the holy of holies, where he stands the gun in the rack, lights his pipe, and sits himself down to peruse the latest copy of the American Rifleman. After a decent interval, during which the gun's owner has been anxiously pacing to and fro like a skipper on the quarterdeck when the glass is falling, the gunsmith appears with the weapon in hand and a triumphant smile on his face. "Try her now," he says heartily, as he thrusts it into the eager hands, "You'll think you're shootin' a different gun." Back goes the happy owner to the trap, after parting with the customary two or three bucks; makes a lucky hit the first shot, and shouts gleefully "That's the stuff! Boy, she's right now! This old gun ain't for sale!" Oh, well.

CHAPTER 32

PISTOLS AND REVOLVERS

THE subjects applicable to all types of firearms, such as fitting and adjusting sights, adjusting trigger pulls, etc., are covered elsewhere in this book under their respective general heads, hence this chapter will deal only with those problems peculiar to handguns.

Due to the splendid quality and workmanship evolved by our leading manufacturers through many years of experience, pistol and revolver troubles are comparatively few. Undoubtedly the best handguns in the world are produced in the United States—this statement is made advisedly, and with due regard for the several excellent specimens produced abroad. And because of their highly specialized knowledge, and unexcelled facilities for doing the work, it is advisable in most cases to have pistol or revolver repairs made in the factory that produced the gun. Sometimes, of course, this is not convenient; there is many a small job which can be done successfully by the owner or by a competent gunsmith; and there are many unique alterations which the factories do not care to handle. But there are also many jobs which should not, in the interest of safety, be entrusted to anyone other than an experienced factory mechanic, even though the delay of shipping the gun back and forth may sometimes prove annoying.

CHANGING REVOLVER BARRELS: This is a job which can be done in the small shop, but which really should be done at the factory. This applies particularly to double action revolvers, in which the left side of frame is cut away to receive the crane. Revolver frames—the double actions at any rate—are not hardened; and it is quite easy to spring the frame badly unless the job is gone at in the right manner. The Colt Single Action Army and Bisley models have case-hardened frames, and there is none of the frame cut away, hence there is far less likelihood of their being sprung.

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The factories of course have fixtures for holding both the barrels and frames, and can do the job without possibility of damage—and if any damage should occur it would be repaired or the damaged part replaced without cost to the owner—and more than likely without his knowledge.

There are times, however, when a man is in a hurry for his gun, and decides to try putting in a new barrel himself, or having it done by a local gunsmith. The first problem encountered is that of removing the old barrel—and its difficulty depends largely on how

the gun has been used, and the condition of the barrel. If the threads are likely to be rusted, then you have a job on your hands. In such case, soak the entire gun in a can of kerosene overnight, then wipe off the oil and warm the frame thoroughly where the barrel is screwed in. Get it good and warm, but don't heat it enough to damage the temper of the metal.

While the barrel is soaking in kerosene, take a couple of hardwood blocks—preferably maple, and cut a half round groove in each, so as to fit snugly against the barrel. Make the blocks three or four inches long, and spot the barrel channels to fit with lampblack, just as the barrel is inletted into a rifle stock. (See Chapter 10.) If the new barrel is the same diameter and shape as the old one, one set of these blocks will do for both—otherwise, make a set for each barrel.

Now when ready to remove the old barrel, dust the grooves in the two blocks with finely powdered rosin, and set them on the barrel. The faces of the blocks should be planed down so they lack about 1/16 inch of meeting. Set them in the vise with the barrel between, and clamp as tightly as possible. The cylinder and other parts, including the crane if a double action revolver, should of course be removed. Insert a stout piece of hardwood, such as a heavy hammer handle into the cylinder opening in frame, close up against breech, and bear down on stick with steady pressure, but without jerking; at the same time tap the part where the barrel is screwed in with a lead hammer, giving several sharp taps while gradually increasing the pressure. Unless the barrel is unusually tight, this will generally start it, but sometimes the wood blocks will not grip it sufficiently tight.

Of course, if the barrel is in such bad condition that it must be discarded, there is no objection to holding it in a vise with pipe jaws, or to holding the frame, properly protected with leather, in the vise, and screwing the barrel out with a Stillson wrench. Such treatment, of course, mars the outside of barrel beyond redemption.

Sometimes when a barrel starts with difficulty, it may be loosened by further heating the frame where it is screwed in with a blowtorch—but be careful not to heat it hot enough to change the color.

When it is desired not to mar the barrel, and it cannot be loosened by the first method, secure a block of cast iron about 1 1/2 x 2

inches, and three inches long. Square it up on planer or shaper, and face both ends square. Drill through it from end to end and ream the hole to the same size and taper as the barrel, cutting a slot in upper edge through which the front sight may pass. The inner surface of the hole should be polished out very smooth. Slip this snugly on barrel and set it in vise, clamping the jaws tight. This will hold the barrel against any pressure you can put on it. Figure 199 illustrates this barrel clamp.

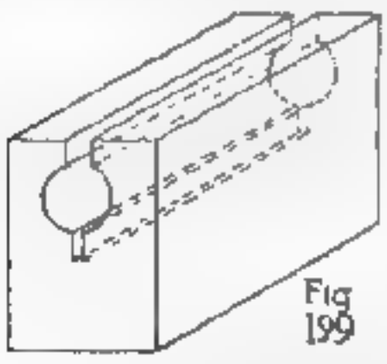

Fig 199

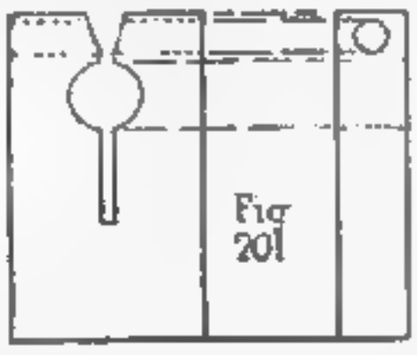

Fig 201

Any of the foregoing methods will answer for removing the barrel of the Colt .22 Automatic, or other arms having barrel screwed into frame.

Never try to hold a barrel in a flat jawed vise with one side of front sight resting against the vise jaw. The sight or sight base is almost sure to give way and bend, or be sheared off, before the threads will start.

FITTING NEW BARRELS: Having removed the old barrel, the threads in receiver should be washed out clean with gasoline on an old tooth brush. Also clean the threads on end of new barrel, and oil them lightly with a thin oil. Screw the barrel into receiver by hand until the shoulder touches, then note how much the front sight lacks of being properly lined up on top. Probably it will require about a quarter turn to bring it to place. Remove the barrel, and file off end of receiver where it meets barrel shoulder. Use a very fine "dead cut" pillar file wide enough to cover the surface at one stroke. Lay the file flat and take a very light cut. Then try barrel again, holding the barrel in clamp or wood blocks in the vise, and setting the receiver up as tightly as possible with the wooden bar. Remove the barrel, and file off end of receiver where it meets barrel shoulder. Use a very fine "dead cut" pillar file wide enough to cover the surface at one stroke. Lay the file flat and take a very light cut. Then try barrel again, holding the barrel in clamp or wood blocks in the vise, and setting the receiver up as tightly as possible with the wooden bar. Remove barrel and note the bright spots on end of receiver, made by pressure of the barrel shoulder. Dress down these bright spots very carefully, using the finest file you have and continue thus until barrel can just be seated with a final hard push on the lever. This "spotting" or dressing

off the bright spots to give the barrel shoulder an equal bearing all round is highly important, particularly in target pistols. The .22 is very sensitive to unequal barrel vibrations, and a firm bearing all round is conducive to best accuracy. This of course applies to larger calibers also, though they are less affected than the .22.

The newly fitted barrel will usually be found projecting too far to the rear of frame to permit cylinder to be closed. Use a 1/2 by 6 inch pillar file, Number 4 cut, to dress down the end. Hold the file perfectly flat, then rock it very slightly toward the side on which cylinder opens, and work slowly and carefully. When cylinder will start past the barrel, but cannot be closed fully, change the angle of cut slightly until cylinder will just close past it. Now polish the end of barrel with a very fine oilstone until the clearance is correct, and equal on both sides. When a .003 inch feeler gauge will just enter between cylinder and barrel from either side, and a .004 inch gauge goes in with a very tight fit, you have about as good adjustment at this point as anyone could ask.

When a new barrel has been fitted to a .22 Colt or other automatic, be sure the extractor cut in barrel is properly aligned with cut in frame. This cut must be properly located even if the sight seems to be off center. The end of barrel must then be carefully filed down so that the slide closes fully, with equal pressure against breech all round. Use a thin smudge of Prussian blue to spot the end of barrel to perfect contact.

With the most careful filing and polishing on end of barrel there is likely to be a small burr left on edges, which must be carefully removed or the barrel will lead badly. A very sharp countersink bit considerably larger than the bore may be held against it and twirled in the fingers, using just enough pressure to remove the burr without beveling the edge. Follow by touching up the edge carefully with the point of a fine oilstone.

REFINISHING REVOLVERS: This is fully covered in Chapter 20, which also tells how to "lamp" small spots in the finish caused by wear. Frequently one will pick up a good second hand revolver which has been nickel plated, and it is very difficult to blue such a gun, because the nickel sometimes goes into the surface of the steel, and resists all efforts to remove it completely. If determined to blue the gun at home, the best plan is to polish until you think all nickel is removed, then apply a coat or two of quick hot bluing solution (Solution No. 1, Chapter 20), which will show up the remaining streaks of nickel plainly, as they will not be affected by the solution. Polish off the spots thoroughly, then repolish entire arm, and blue by the nitre process, finishing with two or three coats of Solution No. 1.

As a rule the better plan in such cases is to take the gun to a first class plater familiar with the Black Nickel process and have the gun finished by that method. The color is excellent, and the

gun is rust proof, and should not wear bright if it is properly finished.

Revolver barrels may be cut off by the same method used for shortening and truing up rifle barrels; Chapter 24. Shortening the barrel of course necessitates fitting a new front sight which is covered fully in Chapter 29, as well as the method of changing an ordinary blade front sight to the "Call" type.

When a revolver or pistol barrel has been cut off for any reason, there remains the problem of providing A NEW FRONT SIGHT and a suitable method of fitting it. The most common practice is simply to cut a dovetail in the barrel, and fit any rifle sight desired. A better way, and one which results in a much more attractive job, is to make a barrel band similar to the Springfield fixed stud, then make a sight, with its lower portion shaped to fit

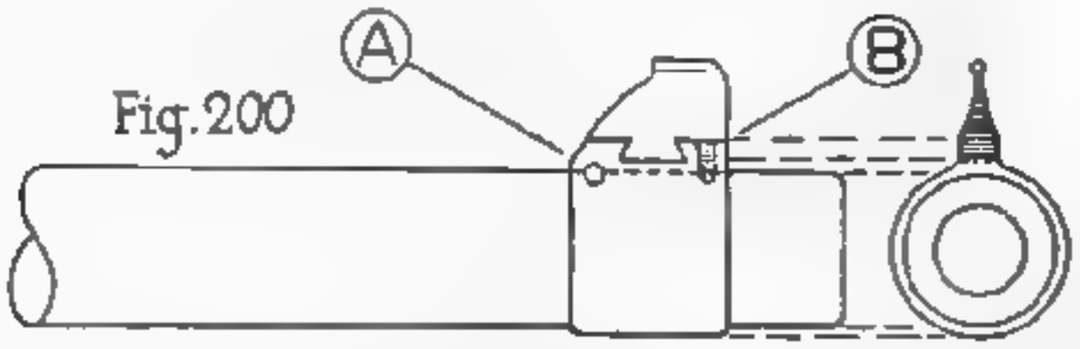

Fig.200

the dovetail, as shown in Figure 200. The band or fixed stud may be made of Shelby tubing, or may be bored from solid metal and ground and filed to shape. The sight may be shaped up and finished in any manner desired,—a round bead, a flat top blade or Patridge, or a gold dot inserted similar to the Call sight. The fixed stud may be attached to the barrel by sweating, or it may be made a snug fit and pinned with a transverse pin biting half its diameter into the barrel, as at A, Figure 200, or a small headless setscrew may be set vertically into the thick portion of the stud, the point entering a shallow depression drilled into the barrel, as at B, Figure 200. Before finishing, the sight should be fitted temporarily on the barrel, and filed to correct height by shooting on a target; then it should be removed and the parts carefully fitted together, polished, and blued, after which they are replaced to stay.

There is no objection whatever to using a low, short ramp on a pistol or revolver—in fact a ramp 2 inches long looks decidedly snappy on a long barreled target gun, and permits the use of any type of front sight desired. The ramp may have a band, and be sweated on in the same manner as on a rifle, or it may be made without a band and soldered to the barrel. Good half-and-half solder will hold more strain than it will ever receive—but if desired, the bore may be coated with file-hardening compound to protect it against oxidation, and the ramp silver-soldered. Use the ribbon solder prepared for brazing bandsaws.

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THE CALL FRONT SIGHT, as supplied to order on Smith and Wesson revolvers is gaining in popularity with many shooters, while others claim they see little advantage in it. This is a wide square blade of the Patridge type with a round gold dot set in the face of the sight near the top edge. In some lights the gold dot shows up bright and distinct against a dark background, while the square edge of black steel gives sharp definition. When using the sights from a darkened firing point the gold is not visible, the sight appearing as a regular flat top blade or Patridge.

There are several ways of adapting this idea to a regular blade front sight. The edge of blade next the shooter should be filed straight and flat; it may be vertical, or may slope forward at an angle of 10 to 15 degrees. Then the hole should be accurately centered so that its outer edge will barely miss the top and sides of blade, and drilled carefully to a depth of about 1/16 inch. A fine jeweler's drill or dental engine will be required—jobs this small cannot be done with a hand drill. The jeweler will either tap the hole and put in a gold screw, or he may melt in a drop of gold solder with his torch. The dentist will doubtless undercut the hole on the bottom and put in a gold filling. I can't see any reason why gold amalgam wouldn't do the trick nicely, but since I'm not a dentist I may be wrong.

The surface of blade which has been filed must of course be reblued, and this can be done without injury to the balance of the gun, by lamping.

CHANGING THE GROUPING. Sometimes a revolver as sent out from the factory will group its shots to right or left, or high or low. When the sights are adjustable, the grouping may be changed as desired, by raising the rear sight if the gun shoots too low, or by lowering the front sight; and by lowering the rear sight or raising the front sight if the gun shoots too high; by moving rear sight to right, or front sight to left, the gun may be made to group its shots more to the right; while moving rear sight to left, or front sight to right, moves the group to the left. In "Pistols and Revolvers," Major Hatcher has given some excellent dope on pistol sight adjustment which should be carefully studied.

On guns having non-adjustable sights the group may be lowered by fitting a higher front sight, or raised by filing down the front sight on the gun, or by substituting a lower one. When such guns shoot to one side, however, the remedy is to move the front sight in the opposite direction.

If it is desired to move the front sight to the left, this can be accomplished sometimes by setting the barrel a trifle tighter in the frame. Usually, however, it is necessary to bend the front sight, and I have found the following method very good:

Take a piece of machine steel about 5/8 inch thick, and drill a hole in it, then ream the hole so that the barrel muzzle may be

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just slipped in easily. Polish inside of hole to prevent marring the barrel, and file out one side as shown in Figure 201. Drill a 1/4 inch hole through from side to side so that a brass rod may be inserted through it against the side of sight. To use, put the barrel through the large hole and clamp in vise, with the small holes opposite center of sight blade. Put the brass rod through the hole and tap it with a hammer, bending the sight as required. By this means the barrel is held rigid and the bend in sight occurs down next to the barrel; and as only a very slight bend is required, it is scarcely noticeable.

On the .45 Colt Automatic, the grouping can be changed laterally by moving the rear sight in its slot. Cutting down this rear sight a trifle will lower the group, while cutting down the front sight will raise it—changes which are seldom necessary. Occasionally one of these guns will be found which throws very large groups, and this can often be remedied, and the gun made to shoot very close, by securing from the factory a new and tighter barrel bushing—this is the small bushing which holds the barrel in the slide at the muzzle. Or the hole in the old bushing may be bushed with tool steel by a competent machinist, then lapped or reamed to a tighter fit on the barrel. There must be sufficient clearance however, so that it can slide easily, or the gun will not function.

Sometimes these guns shoot to right or left because this barrel bushing is slightly eccentric, i. e., the bushing is slightly thicker on one side than the other. A new bushing, or bushing the hole in the old one, will in such cases bring the group to position.

A good many .45 Colt Automatics, particularly those of war-time vintage, are noticeably loose in their construction, particularly in the fit of slide on receiver. This looseness, while necessary to a degree, is not conducive to best accuracy, and much of it can be eliminated with immediate improvement in scores.

Look at the rear end of slide where the grooves fit into grooves in receiver. It will be observed that the grooves fit quite loosely, and that the slide may be "wobbled" from side to side with the fingers. Now remove the slide and strip it of rear sight, firing pin and extractor. Set it carefully in a smooth jawed vise, one jaw of which (protected by sheet brass) rests against top surface of slide, and the other jaw, (bare), resting against the two bottom edges. First, however, "mike" the thickness of slide from side to side, and jot down the micrometer reading. Now very carefully tighten up the vise, so as to squeeze in against the grooves in lower part of slide. Go slowly, tightening only a little at a time. Remove and try for fit on receiver frequently. When the slide will just move in the receiver grooves, but with difficulty, stop. Now mike the thickness of slide from side to side, again, and note whether it has been widened by the squeezing. Probably it will be two or three thousandths wider. Protect both jaws of vise with brass or

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copper, and squeeze sides of slide in until they are the same as before.

Now put a *very little* of the finest emery flour and oil in the grooves, and work slide back and forth on receiver until it just works freely, and with minimum clearance, then carefully wash off all the emery and oil

Now take a very light brass hammer, and carefully tap all along the grooves in slide, trying it frequently until it will just ride the receiver snugly with no side play. Finish by putting a thin coating of Winchester Rust Remover, or Stazon Rustoff in grooves, and working slide in receiver until it runs with no bind at any point. Then wash off clean, oil, and assemble.

MISFIRES. A gun that is addicted to frequent misfires usually needs a stronger main-spring or firing pin spring,—the latter in the case of hammerless automatics operating by a stiff spring driving the firing pin. The trouble may be the result of leaving the gun cocked for long periods, and may be often remedied by stretching out the coiled main spring to about 1/4 or 1/3 longer, then hardening and tempering it as described in Chapter 21. When this does not

prove the remedy, secure a new spring from the factory, or have one made in a machine shop from piano wire, using a size larger wire than the original spring.

Misfires in revolvers are often due to somebody's misdirected efforts to make the gun cock easier, by filing down the flat main-spring. The only remedy is to buy a new main-spring from the factory, or make one yourself from good steel, temper and harden it, and file gradually to a thickness that gives positive ignition. Target shooters sometimes go to extremes in skeletonizing the hammer, to lighten it and speed up lock time—and this lightening of hammer sometimes causes misfires. One remedy is a new hammer; another is a stronger main-spring—this further speeding up the fall of the hammer, though making it harder to cock.

Sometimes in old revolvers having firing pin separate from the hammer, misfires will occur as a result of wear or damage to the point of firing pin, which in some instances may be too short. Secure a new firing pin, or make one from tool steel and harden it, drawing it to a blue color. (See Chapter 21.) If the old pin appeared too loose in the hole, the new one should be made oversize, to fit the hole smoothly. Now carefully round off the end on an oil stone, using a jeweler's magnifying glass to get it properly shaped. Try it frequently in the gun by snapping on primed empty cases, holding the barrel vertical with a small coin laid over the muzzle. Note how high the coin is driven into the air, and whether to the same height each time, and also note the impression of firing pin on the primers. The dent should be full and hemispherical, but not so deep as to puncture the primers. Get some fired shells from a good gun and compare the firing pin indentation. When just right, the point should make a good full impression in primer, without any tendency

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toward puncturing, and should drive the coin two or three feet into the air—and to the same height each time.

If a firing pin is in good shape, but the hole in the revolver frame worn too large, this will often cause misfires, the pin striking near the edge of primer instead of in the center. This may be eliminated by drilling out the firing pin hole to about twice the diameter of the primer, and fitting in an accurate bushing of tool steel, in which the firing pin hole is accurately centered. Such a job should be attempted only by an expert machinist or toolmaker.

CHANGING CYLINDER. Owners of the Model 1917 Colt and Smith & Wesson revolvers often wish to change the cylinder to handle the regular .45 Colt cartridge, instead of the .45 Automatic or .45 Auto Rim cartridges. The change can readily be made, despite the fact that the .45 Colt is a slightly longer cartridge than the ones for which this gun was built.

When you have the new cylinder, measure its length carefully and compare it with the cylinder in the gun, noting the exact difference in length. Now remove the crane and take off the side plate, on which you will note a small projecting lug which holds the cylinder from moving to the rear when swung out for loading. Put the new cylinder into the crane and replace it in the gun. Very likely you will find that cylinder will not close, striking its front end against rear end of barrel where it projects into the frame. If the difference here is slight, it is permissible to file off the rear of barrel slightly, as when fitting a new barrel. Keep the end of barrel square and smooth, and finish it off with a hard oilstone, then carefully remove any slight burr from inner and outer edges.

Now the cylinder, when swung in (closed), must have sufficient clearance between its rear end and rear of frame to accommodate the heads of the cartridges. Some ammunition companies make their cartridge heads thicker than others; so if the cylinder proves a tight fit, try different brands of ammunition. If the cylinder will not close and turn freely with any make, it may be possible to adjust it by moving it further forward. Before starting this, however, note the position of the cylinder lock in the cuts milled for it near rear of cylinder, and be sure they are large enough to permit moving cylinder forward a trifle. If they are, then file off the rear end of barrel as required, and it may also be necessary to file a little off the rear end of crane where front of cylinder bears against it.

Now, when the cylinder closes smoothly, and with just sufficient "headspace" at rear so that it turns freely when loaded, open the gun and note the small lug on sideplate which is intended to prevent cylinder from sliding to rear when it is open. This must be filed back a little so that the cylinder drops in front of the lug, barely clearing it. Do this with a 1/4 inch pillar file and you will run no risk of marring the gun. The bright spot on lug after filing may be "lamped" as described in Chapter 20.

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CYLINDER ADJUSTMENTS. When fitting a new cylinder—and sometimes on the old cylinder as well—it will be noted that the cylinder lock drags, as cylinder is turned, leaving a bright line around it. To eliminate this, carefully polish off the upper surface of cylinder lock, so that it just clears the surface of cylinder. This may be done with the Arkansas slip hone used for adjusting trigger pulls. If the cylinder does not lock tightly, but may be forced out of position with the fingers, it will usually be found that upper edge of cylinder lock is so thick that it is not entering the recess in cylinder. Carefully, and very slowly stone off the sides of cylinder lock, until it will just enter the recesses full depth. When a cylinder has considerable side play even when locked, it is because the cylinder lock is too thin, or perhaps worn down, or the recesses in cylinder are worn at the edges, or perhaps both. The remedy is a new and thicker cylinder lock, which in fitting may be stoned down to fit the recesses very snugly.

CHECKING TRIGGERS AND OTHER METAL PARTS. Triggers, back straps of revolvers, hammers, etc., are often improved by checking to prevent slipping. The principal difficulty encountered in checking steel with the file is that of spacing the lines evenly. One cannot use a checking spacer, since the single light scratch would not guide the tool properly—the checking must be filed in, and about the only way to space it evenly is to gauge it by eye. This is not nearly so difficult as it sounds. Use a 3-square escapement file or a 6 inch needle file with about a No. 0 cut. File in one line and be sure it is straight. Space the other lines from this, cutting them just deep enough to show up clearly, so that succeeding lines may be similarly spaced.

Before starting the checking, the part should of course be polished and coated with copper sulphate solution as explained elsewhere—then the silvery lines show up clearly against the dark copper background.

Having the lines correctly spaced one way, cut the cross lines in the same manner, then go over all lines several times and deepen them until the diamonds are well pointed. Buff on a stiff wire buffer to remove extreme sharpness, then blue.

Slight variations in spacing are more easily corrected in steel than in wood; by simply bearing harder against one side of the cut, a considerable change may be made, because the first cut is quite shallow. With practice a good workman will produce file checking almost as accurate as knurling. There are mighty few parts that are shaped so that a knurling tool can be used on them, which makes reasonable skill at file checking a valuable asset of the amateur.

Deeply curved triggers, and other parts having inside curves are very difficult to check with a file—impossible, in many instances. There are two ways to get around the trouble. Either heat the trigger cherry red and straighten it out, check it as desired, then

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heat and bend it back to original shape and re-harden; or, be satisfied with corrugations filed straight across.

But one of the best trigger surfaces is produced by matting with a very sharp prick punch and hammer, or with the hammer attachment in the dental engine, used in the same manner as when matting a ramp or rib. The sharp stipple surface is attractive, blurs perfectly, and provides a splendid non-skid grip to hand or finger. When matting a trigger in this manner, remember that very likely it will be slightly stretched in the process, and the point of trigger may bind in the guard, necessitating filing or grinding off a trifle when the job is finished.

The reader may recall having seen various Colt revolvers or automatic pistols on which straps and trigger have been diamond checked on special order. Close inspection will show this to be hand work in most cases; and while I have not seen it being done, I am convinced that this is graver work. I recall a trigger on a .22 Colt Automatic, which is sharply checked, the checking stopping at a deep outline around the edge; clearly this is no job for a file, but for a graver in the hands of a very skilled workman. The slight variations incidental to even the finest workmanship are clearly evident.

When checking or grooving small thin parts, triggers particularly, it must be remembered that the checking is subject to practically

no wear, and need not be deep nor coarse. It doesn't take much to keep the finger from slipping off a trigger.

EJECTION TROUBLES. In rare instances the .45 Colt Automatic will develop a habit of throwing the empty cases straight up into the shooter's face. Whenever possible it is best to have this corrected at the factory. If the owner must tackle the job himself, however the first thing to do is to remove the extractor, and carefully hone the lower edge of hook to a slight bevel, causing that edge to release the case head first. This will usually result in throwing the shells well to the right, away from the shooter. Work slowly, assemble the gun and try it often, so as not to cut away too much. A very slight change in the hook will sometimes make a big difference. If you don't get proper results after stoning the hook all you think it will stand, then try beveling the front face of ejector back slightly to the right and down, causing the case to be tripped out of the extractor at a different angle. Be careful, or you will ruin the entire adjustment, causing a jam at every shot. If neither method corrects the fault, give Mr. Colt himself a chance at it, and beg his pardon for monkeying with the gun.

The owner of a large caliber revolver may wish a similar gun to handle the .22 L. R. Cartridge. It is entirely possible, for example, to take the frame of a Colt Officer's Model, and fit it with a specially made .22 caliber barrel; and to turn down the cylinder to proper length and bush the chambers and rechamber for the .22 L. R.

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The amateur who is determined to have such a gun must do one of two things—either be content with a Camp Perry Model S. S. Pistol, or make up his mind to pay somewhere in the neighborhood of $.00 for the job; for it is entirely beyond the ability of anyone other than a toolmaker of the highest order, and a barrel man who thoroughly understands his business.

The barrel must be specially made with the quicker twist required for pistols. Turning down a rifle barrel to size will not answer, as the twist is too slow. This fact was ignored by one factory, in my experience, to the supreme disgust of the owner after he had paid his good iron dollars to have an 8 inch barrel fitted to a .22 Colt Police Positive.

When the Colt factory decided to lengthen the "horn" on the grip safety of the .45 Automatic, they rendered a real service to the chap with a large hand which was pinched and gouged between the hammer spur and short grip safety each time the gun was fired. But—they reckoned without knowledge of my good friend Carl Schilling, whose hand looks just about like any other man's hand when he is not shooting the .45 Auto. In that case, after emptying

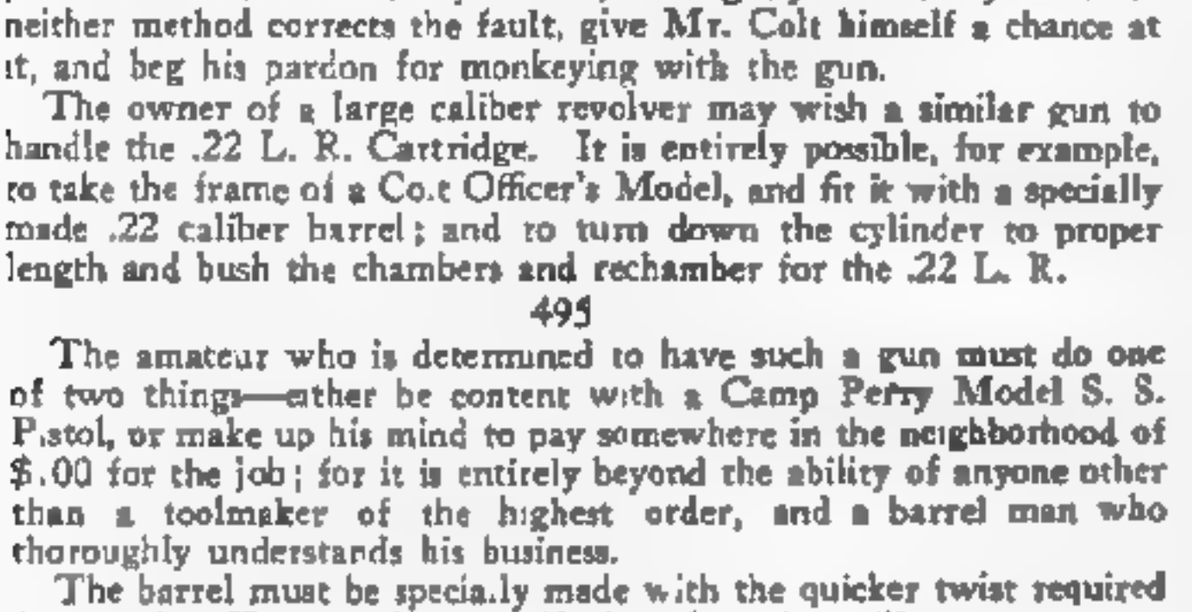

Fig. 202

one magazine, it looks more like something the cat had dragged in after it was run over with a harrow. Carl's hand is very heavily muscled in the crotch of the thumb, and the improved grip safety didn't help him a bit—if anything, it gouged out the flesh even worse than the old model. Despite his liking for the .45 Auto. he had definitely decided to discard it for good, when I suggested the remedy illustrated in Figure 202. The photo shows how the gun looked when the job was finished, while Figure 203 shows the

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job in process. "A" is the original grip safety; "B" shows it with the lower side of spur filed out to receive the extension; "C" shows the extension roughly filed from cold-rolled steel and fitted, with an 8-32 countersink-head screw to hold it in place. A piece of thin ribbon silver-solder was then fitted between the two pieces and the screw set up snugly, then the assembly heated redhot with a blowtorch causing the silver to melt, firmly brazing the parts. The screw was then set in as tightly as possible, and the head, which was slightly countersunk, was peened in tight, then head and point of screw filed off flush, as at "D," and the extension filed to shape; after which

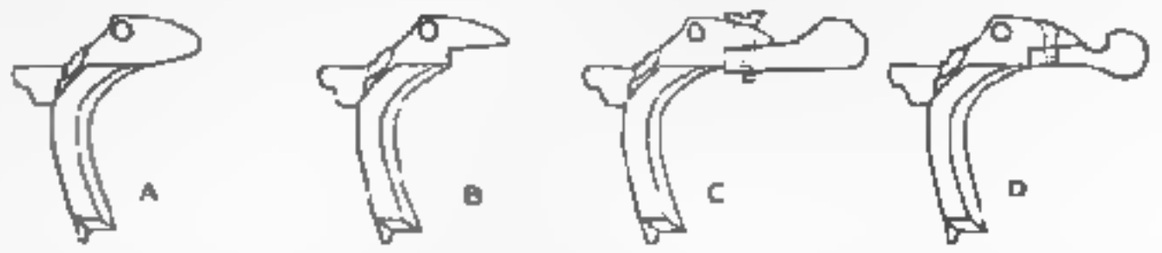

Fig. 203

the part was nitre blued. After trying the gun with this alteration Carl was so tickled he immediately bought another which underwent a similar grafting operation before it was fired; and while some think this "fiddle-head" looks funny, Carl swears by all that's holy that the way it presses into his hand holds the gun much more firmly; and the hammer spur is absolutely prevented from doing any damage to his "mitt."

"BUSTED" REVOLVERS. Accidents will happen, even in the best of families! Figure 204 shows a Colt Officer's Model that "let loose" in the face of some ten or more grains of Bulls-eye—the result of an adjustment screw having slipped on a powder measure. Happily the pieces of brass and cylinder which blew off missed the owner completely, the only damage noted, outside the gun itself, being to his peace of mind and his undies!

Of course the usual claim of "faulty gun" was presented to the folks in Hartford, but they, being wise to the ways of this wicked world, promptly denied the allegation and defied the alligator. Moreover, they kindly offered to repair the gun with a new frame and new cylinder, for the trivial sum of thirty-nine dollars and fifty cents. Just how they "figgered" is beyond my ken, since $40.75 will buy a new gun, and the total value of barrel and action parts, grips, et cetera, none of which were damaged, is quite a little in excess of $1.25 according to the parts price list. So old man Beals sat himself down to cry and to curse, and bemoan his fate—until he happened to remember of one George Titherington of Stockton, California, whom he met at Perry. Accordingly and forthwith, a photo of the busted gun and particulars thereof were posted to George, who allowed as how he might do it some good, since he was sure he couldn't make it any worse.

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The insert in Figure 204 shows the gun as it looks today, after the aggressive "Native Son" finished with it. The top strap of frame was straightened out, and the break, which occurred in the rear sight dovetail, welded, then a new dovetail cut for the sight. A new cylinder fitted perfectly, as the frame was bent into line again. The gun today seems as good as ever, having been shot considerably with full loads with no sign of weakening or giving way. I may remark that I have never seen a finer job of welding than was done on this gun. The weld is absolutely invisible, and appears one piece of metal, although Mr. Titherington merely heat blued the strap,

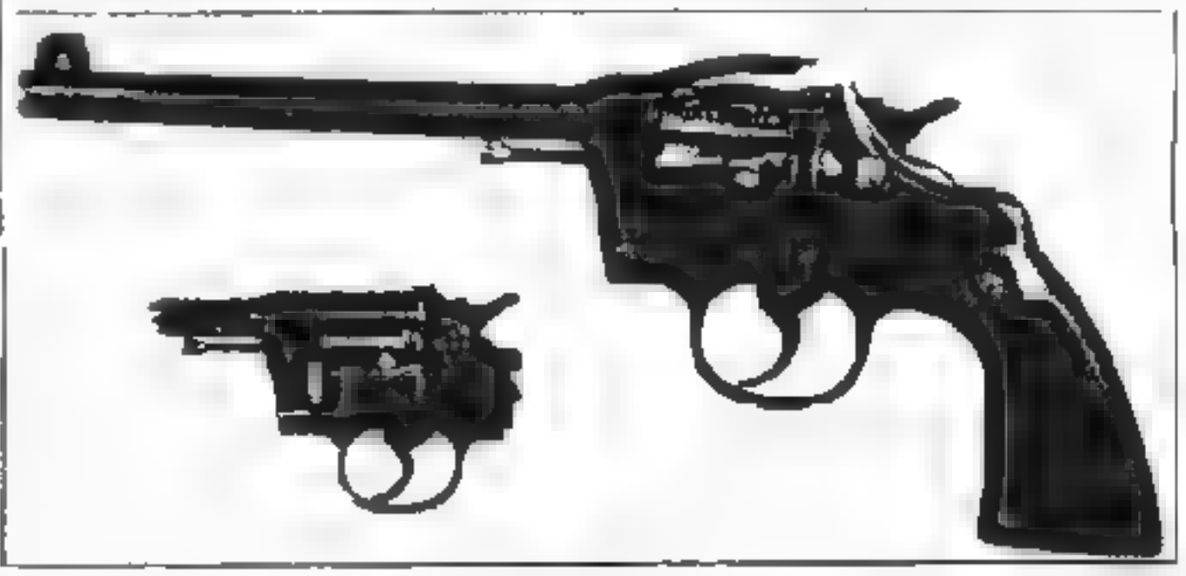

Fig. 204

which would tend to show the break unless the weld was perfect. Incidentally this repair cost the owner of the gun about $12.00 including the new cylinder.

Complete details of the job, as reported by Mr. Titherington, are as follows:

"I took an acetylene torch and carefully heated the top frame strap to a low cherry red and very carefully hammered it down to place, first cutting off a little of the broken end of strap about 1/16 inch, as it was slightly stretched. Then I welded this broken end at the rear sight slot, afterward dressing down the frame smoothly, doing a little filing at rear of frame to get proper headspace.

"Where the front of frame was bent (in the thin part where front of crane touches), I found the barrel was about 1/16 inch higher than center, so this was bent down cold in the vise. The hardest job of all was to get the short kink out of the crane stem just in front of cylinder, which was caused by the downward thrust of the chamber when the top of cylinder hit frame strap, when the cylinder walls let go. This was accomplished by fitting a pin inside the stem down to where the first kink was, to prevent the stem from getting mashed together and made out of round. I then heated the kink with the torch and drove a wedge between crane stem and crane hinge, until the stem was again straight.

"The frame was also bent so that side plate fitted poorly. This was straightened and sprung back cold, in the vise."

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Grips for revolvers and pistols are excellent objects for the amateur gunsmith to try his skill and inventive genius on. For one thing there is very little material to spoil, and experiment can be made with a number of walnut grips without running into much money. In cutting out rifle or shotgun stock blanks, one usually has a quantity of scrap left, and often this will be of the most beautiful curly grain. Saving this scrap affords the worker an unlimited quantity of pistol grip material at no cost.

No expensive outlay of tools is required, for one or two chisels, a rasp and a file are about the only things needed. A small iron vise which may be clamped to the kitchen table will serve in a pinch, although a good bench and heavy vise are desirable to any job.

And this work promises much, for a well-fitting set of grips moulded to the shooter's hand will greatly increase his skill with the weapon. The fit of the handgun stock is of quite as much importance to the shooter as the fit of rifle or shotgun stock. One can also exercise all his artistic ideas in grips, carving or decorating them as he sees fit—and he can't spoil the gun, for the old grips are easily replaced. Some wonderful works of art are seen in grips on pistols and revolvers, particularly those from the Orient and our Old West.

I am reminded of some lines which I once saw beautifully engraved on the ivory handle of a Peacemaker carried by a deputy sheriff in south Texas some years ago:

"Be not afraid of any man,
No matter what his size;
When danger threatens, call on me—
And I will equalize!"

So impressed was I with this sentiment that I formed rosy pictures of this old timer some day passing out with his boots on in a blaze of glory and a cloud of powder-smoke. But alas for human frailty! The old chap cashed in by the very prosaic process, of getting drunk and turning his flivver over in the ditch, breaking his neck.

Grips may be made of hard rubber, bakelite, aluminum, walnut, rosewood, ebony, maple, apple, cherry—in fact, any hard, close grained wood; they may also be made of buffalo horn, stag horn, cow horn, mother-of-pearl, ivory, walrus ivory, or many other materials. The shooter may desire to copy one of the old steer-head stocks often seen on six-shooters in the west; or he may wish to depart entirely from the conventional shapes and model his grips to conform exactly to his hand, with grooves for each finger.

One method of arriving at the perfect hand-fitting shape is to take a large lump of dental wax or modeling clay on each grip, and grasp it firmly as in shooting. The wax or clay will then model itself exactly to the hand, taking the impression of each finger, and when

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dry, forms a perfect mould or pattern to follow in making the new grip.

Another way which I like better is to first make and fit on a couple of thin slabs of soft pine; then spread on them a thick layer of Plastic Wood. Oil the hand slightly to prevent sticking, and grasp the handle of gun, then let the wood dry, when the shape will remain. Plastic Wood may after drying, be filed or sanded as required to get the shape just right, and the gun may be fired on the range until one has the grip just as he wants it. Additional Plastic Wood may be added at any point, as required—for actual shooting sometimes shows up faults that are unnoticed when merely pointing the gun. When you have the grips exactly right, you can then copy them in walnut or other material, or send them to a gunsmith to be duplicated.

If walnut is used for grips, select a piece of the hardest, closest grained wood you can find. Scraps taken from stumps, or near the stump, are always better, and besides have fine figure as a rule. Soft, easily split wood is worthless for pistol grips. Circassian walnut of good quality makes excellent grips—when you make your rifle stock, very likely you can saw off a pair of pistol stocks from it.

Blanks for grips should be very much oversize all round, and each pair should, if possible, be made from one piece of wood, particularly if well figured. Saw the piece roughly to shape, and have it at least twice the thickness required. Then split the piece with a ripsaw, using the two halves "inside out" which will make the grain identical on outside of each grip.

If the outline of grip is to be larger than the frame of the gun, the front and back straps must be inletted into the wood just half their depth. Follow the same general methods used for inletting rifle actions, cutting the outlines straight into the wood with straight or hollow chisels as required, and scooping out the excess wood with a slightly curved chisel. "Spot" in the straps with lampblack and oil, and when the two edges of wood must meet outside the straps, be sure the edges are in contact all over their surfaces—otherwise when the outside is shaped up there may be an ugly gap appear between them.

When the slabs are fitted, drill the hole for the screw which holds the grips, and let in the small escutcheons or bushings taken from the old grips—or use new bushings purchased from the factory. If the grips are to be thicker than the old ones, these bushings must be sunk below the surface, or a longer screw procured or made. Having the slabs fitted to the gun, the grips are shaped up with rasp and file. The easiest way is to hold the gun in a vise by the barrel, which should be well protected from the jaws by a wrapping of leather or felt. Be careful not to let the file or rasp touch the gun at any point. Work as close as you dare; trim along the edges with a very sharp chisel, and remove the grips for final shaping.

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Use a small wood screw to attach the grip to the edge of a narrow piece of wood, which may be held in the vise.

After shaping, sand the grips, smooth, then wet them and sand off the "whiskers" as described in instructions for finishing stocks in Chapter 13, after which they may be oiled and checked, carved or otherwise decorated. (See Chapter 12.)

Figure 205 shows a pair of "free pistol" style grips made for a .38 Colt Military Model automatic. Here is an excellent cartridge, but with one of the most poorly designed guns ever made from a

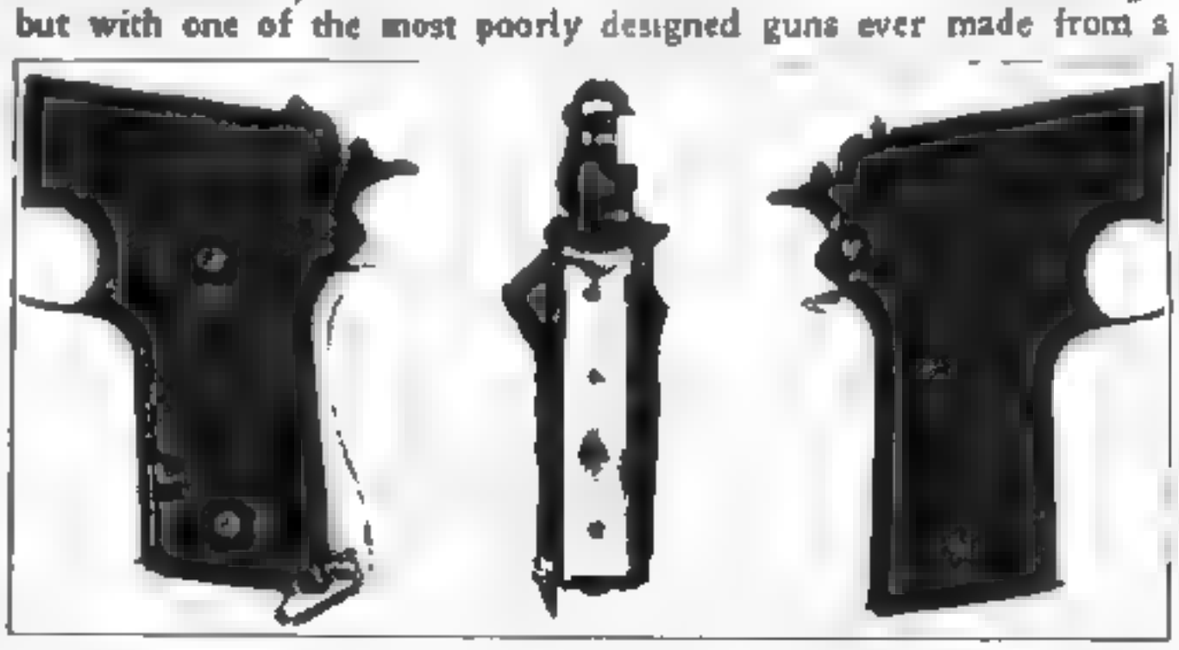

Fig. 205

standpoint of hang and balance. The new grips, while of course not changing the angle of the grip, greatly improved its hang and handling qualities by changing the position of the shooter's hand, and providing a firmer hold.

A friend of mine showed me a pair of smooth walnut stocks he had made for a S. A. Colt. He told the gunsmith who made them that he wanted no checking or carving, wanted a smooth finish, yet one that would not slip in the hand. The gunsmith finished the grips with orange shellac, into which he mixed a little finely powdered

p .nice. The grips had a very brilliant finish which showed off the beautiful grain to perfection, yet one could have struck matches on them if necessary!

This same party was troubled by frequent misfires in his favorite pocket weapon—a Remington double derringer. He has corrected this fault by taking the hammer to a brazing shop, where a good sized gob of phosphor bronze was melted onto the hammer spur, then rounded off and filed smooth. It now makes little difference how old or stale the .41 rim fire cartridges—when this hammer is driven down by the main-spring, assisted by the weight of that chunk of bronze, things happen!

Getting back to grips, the space back of the trigger guard, between

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g uard and grip, on some revolvers, permits the shooter's hand to slide up too high for a steady firm hold. By fitting new grips, letting the wood extend forward to the guard, the grip may be greatly im- p oved. Some shooters use the improv.sed method of filling in this s,ace with a piece of wood or rubber, held by wrappings of tape. A better way is to file out a block of machine steel to the shape de- s ed, and fasten it in place with a filister-head screw set in flush with the surface. A still better plan, if the gun needs rebluing s nyhow, is to braze or weld this piece in place, dress it off smooth, and refinish the gun.

A word about aluminum grips. This is an excellent material, with possibilities that are frequently overlooked. Sometimes one may merely want a pair of unbreakable grips same shape as those that came on the gun. The factory grips may be used by an alumi- num foundry as patterns, and new grips cast which exactly duplicate the walnut ones, even to the metal medallion and the checking. Much progress has been made in the casting of aluminum, and a first class foundry will produce castings so smooth that very little finishing is needed. Just retrace the checking with a three-square file and smooth up the edges. To allow for shrinkage, glue a very thin layer of soft wood, or piece of cardboard (about 1/32 inch thick) to back side of grips, and bevel the edges to correspond with edges of grips with a very sharp file.

The checking on aluminum grips does not wear smooth like wood, and the natural color of the metal on a revolver is not unpleasing. The grips may be given a black finish if desired, by the process described for blackening aluminum in Chapter 20.

"Handful" grips of aluminum are easily made by first working up pattern grips from plastic wood as previously described, then sending them to the foundry for castings, which can be scraped and filed smooth, polished, and file-checked as required. It is not necessary to check aluminum grips unless desired, however, as this metal sticks to the hand well even when finished smooth.

BROKEN PARTS such as sears, triggers hammers, hands, etc., are best replaced with new factory parts. In a pinch they can be made if not too complicated in shape, from high grade tool steel, and hardened and tempered as described in Chapter 21, but the factory parts are easily secured, and usually require little fitting. When filing out a hammer, trigger, or similar part having a pivot or screw hole, the hole should be drilled in the stock before it is shaped up. Then insert the drill through hole in new stock and old part to keep them properly aligned, and hold both parts in the vise while filing the new one down to size. This will save a lot of time and many cuss words.

Figure 206 shows two Stevens Model 35 single shot pistols, one with the original hammer and trigger, the other with new parts made of tool steel. The owner of the first gun wanted a 3 1/2

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pound pull, and was satisfied with the handling of the gun other- wise. The pull was worked down as desired, but due to the soft- ness of the parts, it will probably wear lighter in a short time, al- though it has held up very well through about 600 shots.

The pull on the second gun was similarly lightened, and the parts then hardened in cyanide, as they appear to be made of nothing better than machinery steel. However, the sear end of trigger is very thin, and the hardening was carried too far, resulting in the sear point breaking off. Since the owner had complained about the small grip and the trigger setting back too close to his hand, I made the new hammer and trigger from 85 point carbon steel, hardened them and tempered at medium brown straw color. The hammer was made twice the width of the original hammer and cut

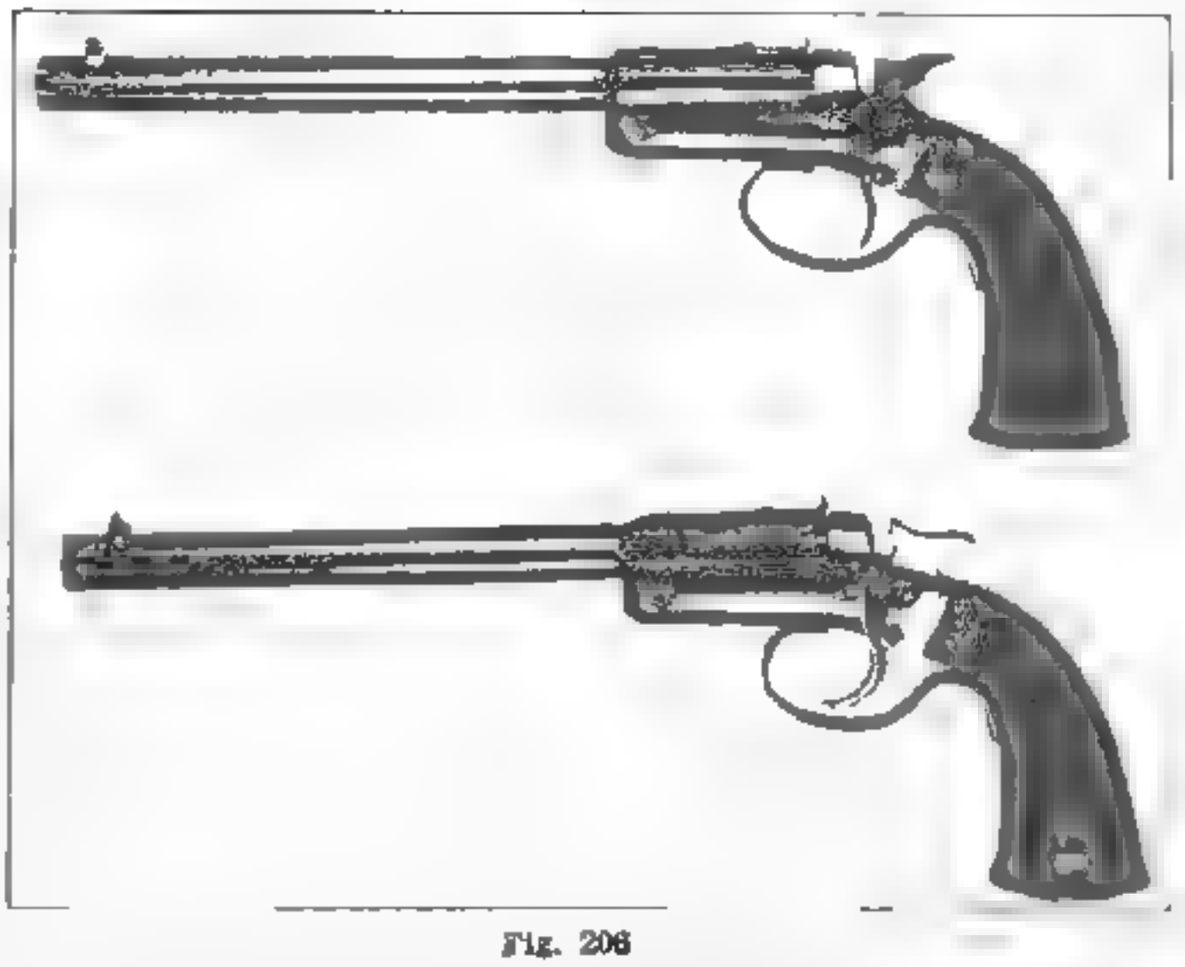

Fig. 206

away on the sides to fit closely in the frame. Trigger notch was cut higher to shorten the fall, and the spur was lengthened and set lower, so that it does not cross the line of sight—the original hammer showed up slightly in the rear sight notch. The trigger feels much better in a man-size hand, and it has a permanent pull of 8 1/4 ounces—and is guaranteed to plumb ruin a man for shooting any other gun having a normal pull. But great Jupiter!—how you can lam the bull-frogs with this old potiron.

These parts were made entirely by filing and the screw holes

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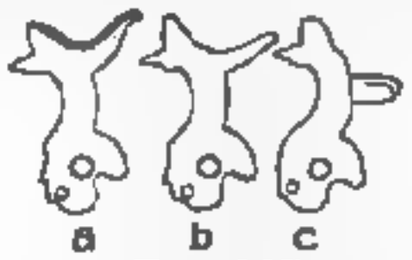
drilled with a breast drill, and, discounting the exceptionally light pull, they improve the handling of the pistol at least 100 per cent.

The Peacemaker addict is a natural born tinkerer. Likely as not he will object to the big high spur on the hammer of his Single Action, and want to bring it down out of the line of sight, so he can call his shots. To do this, first remove hammer and drive out the drift pin which holds the firing pin in place. Then drive out firing pin from the rear. Clamp lower part of hammer firmly in vise, the jaws of which have false jaws of sheet brass, to pre- vent marring. Then heat the hammer spur where it joins body of hammer with a welding torch, to a bright red. Keep tip of spur below this heat if possible. Do not pound on the spur, but press it down with a piece of brass shafting, to the position desired. When cool, the hammer will be soft and the sides may be dressed down smooth with a file and polished, after which it should be thoroughly case-hardened. See Chapter 22. Due to the bending the firing pin may not enter to proper depth. The rear end of pin may be ground off slightly, or the hole in hammer may be drilled deeper, using a drill the same size as hole was originally—this of course must be done before hardening the hammer. When hardening, be sure to do a good job on the trigger notch, otherwise the pull will not remain permanent.

Sometimes the hammer spur is cut down smaller before bending, but this is not necessary. Figure 207 shows the Colt S. A. hammer spur as Colonel Colt designed it, compared with two well known al-

FRONT SIGHT



a b c

Fig. 207

terations, "b" being the Peret, and "c" the Newman hammer, the latter designed to slip from under the thumb, the trigger being re- moved from the gun.

When the spur is altered the line of sight is not obstructed except momentarily, by the nose of the hammer in falling. A small amount

ground from hammer nose will eliminate even this small objection.

ALTERING COLT S. A. REVOLVER TO SHOOT SHOT. Bud Dalrymple, U. S. Hunter, started it all out in Wyoming some several years ago, and wrote so enthusiastically about his six-shooter scatter guns, that he got a lot of mouths to watering for some of the same. I don't know what Bud's method was, exactly, but the following worked out O. K. for me and doubtless will for others:

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First, secure an old revolver of large caliber, with a barrel that has seen its best days. The .45 Colt S. A. is best, with the .44-40 running a close second. Don't expect satisfactory results from a barrel shorter than 7 1/2 inches. Ten inches would be better, and an old rifle barrel of the right size can be utilized if you have a lathe that will cut the thread. However, the regular 7 1/2 inch Peacemaker barrel gives very satisfactory results.

Remove the barrel and set it firmly in the vise in any convenient position. Measure the bore with a lead slug as described elsewhere, then using the micrometer as a guide, set a 6-blade Critchley adjustable reamer to as nearly as possible the same diameter. Use a d'e-holder as a handle for the reamer, and use plenty of the soda-water-and-oil cutting compound as a lubricant. Probably the No. 19 or 20 reamer will be required, depending on size of bore and its condition. At first the reamer should turn through just scraping the lands, cutting little or none. After this first scrape cut, set back the adjusting nuts of the reamer not more than 1/16 to 1/8 of a turn, increasing its cutting diameter very slightly. Make all cuts from breech to muzzle, and make the cuts *as shallow as possible*. Remember the reamer blades are nearly half as long as the barrel, and this isn't like reaming a hole in thin stock. A reamer "frozen" in a hole is about the biggest cuss producer I know of. It should take from six to fifteen or more cuts to remove the rifling, and when this is removed, stop. Cast a slug on a short rod and lap the bore freely with No. 120 emery and oil, using long even strokes from breech to muzzle. Then measure carefully the cutting diameter of reamer at rear end of blades, and also at front end. These reamers have from five to eight thousandths taper for about half of their length, to permit easy starting. Whatever the taper on your reamer proves to be, set it that much larger for this last cut, and turn it through the bore until front end of cutting blades are barely even with the muzzle. Thus the bore is choked an amount equal to the taper of front end of reamer.

If the taper is considerable, say seven thousandths, it is best to do this choke reaming in two or three cuts, never letting the front end of blades pass the muzzle—otherwise the deep cut may cause the tool to chatter, or perhaps to stick. Take a final cut without enlarging the reamer, to burnish the hole and help eliminate marks. Then cast a lap about two inches long in muzzle end, so the lap will have the taper of the choke; coat it very lightly with finest emery flour and oil; chuck it in a breast drill, with a rubber hose connection in the rod, as described under instructions for polishing shotgun bores (Chapter 31), and whirl it inside the barrel, at the same time drawing it backward and forward, until the main portion of bore is from seven to twelve thousandths larger than the muzzle, and the tapered choke from one to two and one-fourth inches long. Now polish the bore lengthwise, using this same lap

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at first, and later another lap, also cast in the muzzle so it has the taper of the choke. Use emery flour at first, until all cross marks and reamer marks are out, and the bore brightly polished; then use the various finer abrasives recommended elsewhere for bore polishing.

Apparently a shot charge fired from a pistol barrel is more easily affected by a damaged muzzle than when fired from a shotgun barrel of average length; so it is recommended that the muzzle be carefully crowned to assure its being square and true.

Before putting in the barrel, remove the cylinder and ream the chambers carefully to remove the slight shoulder at the forward end. Use an expanding reamer of the proper size and be sure not to enlarge the body of the chamber one bit. Set the reamer so that it barely cuts in the neck portion; expand it a very little each cut; use plenty of the cutting lubricant, and when the blades show signs of touching the chamber walls in the larger end, stop. Follow instructions given in Chapter 27 for lapping and polishing chambers to same size, using great care to enlarge them the least possible amount. Most Single Action chambers are sufficient oversize to begin with, without making them larger.

Now check up on the action of the gun, make any necessary repairs or adjustments, see that the cylinder aligns properly, and screw in the barrel. But first measure the bore at extreme breech, and "throat" it to about fifteen thousandths larger than front end of chambers. The best tool for throating is the G. T. D. spiral fluted burring reamer No. 246, with T handle, tapering from 1/4 to 2 inches; and the best way to use it of course is in the lathe, with the handle removed; but lacking a lathe turn it by hand. The throat should extend forward into the barrel about 1/4 inch. After reaming, polish out the throat with a lead lap cast to fit it, and a little fine emery and oil. No great amount of polishing is necessary here—just smooth up the cut and get rid of tool marks.

Do not set the barrel tightly in the frame yet. It makes no difference if the sight does lean off to one side. Pattern the gun with different size shot at ranges of 10 to 25 yards and see what it does. It may be necessary to lap the muzzle a bit larger, or perhaps to increase the choke by enlarging the main portion of the bore. Keep at it until it suits you, at the same time experimenting with loads until you have the right combination of shot, powder charge, bore and choke to enable you to bowl over the festive bunny up to twenty yards or more, or to shatter the head of a diamond-back at forty feet, and you'll say the fun is well worth the trouble. When you are satisfied with the pattern, set the barrel in tight; bring the pattern where you want it by bending the front sight right or left, and filing it down as required—or put in a Marble or a Lyman ivory shotgun front sight.

Any large caliber revolver may be adapted to shoot shot in this

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manner, and in addition to the fun it provides in woods or field, it should prove excellent medicine for the midnight intruder—without endangering the neighbors in the next block. Ammunition must of course be made up special, which will make one of these six-shooter shotguns an attractive proposition to the handloading nut of an experimental turn of mind. To provide sufficient pressure to burn the powder charge cleanly, it will be necessary to crimp the case muzzle heavily over a stiff card wad. Experiments should start with black or semi-smokeless powder, or bulk shotgun smokeless, although I imagine a load could be worked up with du Pont No. 80, and perhaps with Bullseye or No. 3 or 5. I have altered but one gun in this manner, and the owner is now doing the experimenting with loads.

I have often been asked for a dependable method of preventing the frame screws from working loose in the S. A. Colt. I know of just two ways of overcoming this difficulty. One way would be to tin the screws and sweat them into their holes so they couldn't work loose—and the other, which I follow with my own guns, is to carry a small screwdriver and tighten the screws every few shots. If anyone has a better suggestion, it will be thankfully received.

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CHAPTER 33

RESTORATION AND REPAIR OF OLD FIREARMS

THIS is always an attractive subject to the dyed-in-the-wool gun crank, and one in which even the most skillful mechanic can make serious mistakes. The acquisition of some old-timer from the attic or the pawnbroker's window immediately releases the imagination, conjuring up pictures of how the ancient weapon must have appeared in all her youthful glory, and an uncontrolled yearning to restore her pristine vigor. Yet the misguided efforts of well-meaning gunowners frequently bring about results as ghastly as a snowy-haired grandmother in lip-stick and mascara smoking gold-tipped cigarettes. Modernization *can* be carried too far, for while Daniel Boone undoubtedly possessed the stamina to enable him to make a very respectable drive from the first tee—we do not care to think of him in tweed knickers and fancy sox. As a friend of mine stated it recently, "Adam would have looked like hell in a plug hat."

Some splendid thoughts along this line have been expressed by Captain John G. Dillin in his book "The Kentucky Rifle"—the which should be in the hands of every lover of firearms, by the way. Captain Dillin writes from the standpoint of the collector when he states:

"Should the collector, discovering inherently fine examples in such condition pass them by or, acquiring them, feel a hesitancy in restoring them and regarding them as fit for inclusion in his collection as originals? There would seem to be no good ground for such a course, *provided that the restoration is accomplished by honest replacement with old parts, wherever available, and that the period of the piece is faithfully retained.*"

"In instances where the collector is desirous of putting the piece into shooting condition, as many of them do today, it may be considered permissible to remedy such small defects as missing frizzens, springs and even pans by the fitting of new parts, if the parts are honestly hand made, and not mere cast iron junk."

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I have frequently refused (to the extreme disgust of the inquirer) to accept a job of altering or remodeling an old firearm which would cause it to loose its original identity. Not long ago a man was somewhat put out because I strongly advised against his pet idea of remodeling an ancient cap-and-ball Colt to shoot the .38 Special cartridge! He had the details all planned, and wrote me long letters full of sketches and explanations of welding, drilling and bushing operations. I begged him to give the old gun a square deal; to retire it honorably from service, as it deserved. I explained carefully that the work he demanded would run into more dollars than the cost of an Officer's Model, or an S. & W. Military, target grade. He shed all arguments like a duck sheds water, and has no doubt by this time found some chap with a lathe in the back end of a garage who will jump at the chance to desecrate the honorable weapon.

When I have fired my last shot and passed on to my everlasting reward or punishment as the case may be, it is my fond hope that I may be able to return to this "vale of sorrers" long enough to plug up the barrels of the guns I leave behind me, should they fall into the hands of those morons who wish to adapt them to use in a future century.

THE RECONDITIONING OF AN OLD GUN, provided it is not wholly beyond repair, is perfectly legitimate both from the standpoint of the collector and of the practical crank who wants to shoot the gun. Whatever work is done on it however, should be with the idea of making it truly typical of its period. If the finish is to be restored it should follow the original finishing process, if this is known, or at least one of the processes of the period in which it was built. The grafting of a pistol grip to the stock of a fine old percussion rifle is nothing but sacrilege, for it disposes of the ornamental brass guard which served the first owner in lieu of a pistol grip, and gives no conception of the feel or handling of the arm in its days of service. Yet I have seen a man proudly display a high grade and perfectly authentic flint-lock rifle, to which he had fitted a Lyman peep sight.

It is entirely permissible, of course, and often most interesting and practical, to remodel certain obsolete types of arms making them useful as more modern sporting weapons. But a gun that is rare, and of real historical value as representing the type in use during a certain period, should have its original condition preserved. Many a man who lacks appreciation of an old gun's worth, will want to "have dad's old musket made over into a britch loader," in the common fallacious belief that "they used better metal in them days." The fact is that the converted muzzle loader is about the most useless and unreliable piece of hardware a man ever carried afield. Its barrel and breech action lack the strength necessary for shooting modern ammunition—yet its owner may proudly boast of its superior quality to the best products of the factories today. I had occasion recently to see the result of shooting a heavy charge of Ballistite in a fine old Damascus barrel; it simply unwound itself as from a mandrel. The only bright spot of the occasion was that the erring owner received a rather severe cut on his cheek as a fitting retribution for feeding hard licker to an old timer that should have been on a milk toast diet.

The collector who secures a really good antique arm, will be desirous of bringing it into the best possible state of preservation, and possibly putting it into shooting condition. He should enter upon the task advisedly, and after mature deliberation. Often a real treasure may be found so encrusted with rust and the dirt of years that its identity is hidden—and hasty or injudicious use of harsh cleaners may quickly ruin it.

The first step should be a careful and minute inspection of all parts of the gun with a good reading lens, or, better, a jeweler's magnifying glass. Look particularly for cracks in the stock near the breech. This seems to be the weak point of most of the old stocks. If cracks are in evidence, the greatest care must be exercised in DISMOUNTING THE GUN, to avoid increasing them.

Having become familiar with the gun's exact condition, remove the stock by first taking out the wedge pin or pins in the forend. Use a piece of hardwood to drive with, and be careful—the pins may be rusted fast. The breech pin tang may or may not have a screw extending down into the forward portion of grip. Remove this carefully with a strong well fitting screwdriver. Then lift out the barrel. Sometimes the underside of barrel will be rusted, causing it to stick in the wood. A few light taps with a block of hardwood should loosen it without damage.

Next remove the breech pin using a smooth jaw wrench, and holding the barrel firmly in vise, with the jaws protected by sheet brass. Now carefully inspect the bore. Very likely it will be so covered with loose rust as to make any definite idea of its actual condition impossible. Secure a strong steel rod long enough to reach clear through, and thread one end to take the brass wire cleaning brushes. Give the barrel a thorough brushing dry, and shake out the loose rust. Now dip the brush in Hoppe's Nitro Solvent, and scrub it thoroughly. Swab with several dry rags, and inspect carefully.

This scrubbing with brass brush and No. 9 may be continued for hours in many old barrels, the rust, like Tennyson's brook, seeming to go on forever. Much labor may be avoided by corking one end of bore and pouring in a bottle of the oil, letting it soak for several days, following this by a good scrubbing, and further swabbing with cloth patches, until the true condition of the bore may be noted. If desired merely to clean up the gun, this is about all the cleaning the bore should have, except that it should have several quarts of

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boiling water poured through it to kill further rusting action, after which it may be polished with oiled patches and finely powdered pumice.

If you want to put the barrel in shooting condition, further work will be necessary. First wrap a small quantity of fine steel wool round an oiled patch on the cleaning rod, and scour the bore a few times with it. This gets to the bottom of the pits, knocking out any more rust that remains, and gives you an idea of their depth. It is now up to the owner to decide whether or not to lap the bore—and the decision will be governed partially by its size. Measure the land and groove diameter carefully, and look for some source of ammunition. If you have a mold about the right size, find out if the ball it casts can be used in the rifle. If it just slides down the bore loosely, it may be right with the proper thickness of patch. If the ball is too tight, you will be safe in lapping the bore considerably. If too loose, or if it appears that it will be too loose after lapping, a thicker patch may solve the problem.

Having decided to lap the bore, follow instructions as outlined for more modern arms as explained in Chapter 26. In very rough barrels it is permissible to start the lapping with rather coarse valve grinding compound made of carborundum. Follow this with further lapping with finer abrasive, and finish with No. 120 emery and oil, casting a new lap as the ones you are using become too loose.

RECUTTING A BORE. When a barrel is in very bad condition it may prove quicker and more satisfactory to rebore and rifle it. This can be done without any special equipment such as the gunsmith used in making the barrel; even a lathe is not necessary. Use a lapping rod about 1 foot longer than the barrel, and with a strong swivel handle. Turn up a steel head for the rod as shown in Figure 208, with a slot milled in the flattened portion to hold the cutter or "saw." This head should be a smooth sliding fit in the bore. The saw is made of tool steel, the cutting edge slightly rounded as shown, and its thickness should be equal to the grooves in the barrel. The shank above and below the cutting head should be roughly jagged to hold lead.

Before fitting the cutter into the slot, insert this head, which should be strongly welded or brazed to the lapping rod, clear through the barrel so that its upper end stands 1/4 inch below end of bore. Pour in melted lead to form a lap on this end. Now draw the rod toward other end of barrel, until the head stands three or four inches below the end, and holding the rod carefully centered, pour in melted lead, forming a second lap, as shown. These two laps are merely guides to assure the cutter following the grooves. The

cutter slot may be milled in the head after the two laps are cast, the lands on the lead forming an accurate guide for the location of the slot. The first laps used for this purpose should be melted off and new ones cast as just described for the actual work of rifling.

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After the final laps are cast, withdraw the rod just enough to expose the cutter slot; insert the cutter, coat laps and cutter liberally with oil (preferably lard oil), and push through the bore until the end of cutter partly projects from the opposite end of barrel. Now draw the rod carefully the full length of barrel. Note whether the cutter has "taken hold." If not, shim it up with thin paper until it does. The sloping bottom of the slot in head permits a release of pressure on cutter during return stroke, thus preventing wear to the teeth. When the cuter will just start cutting, count carefully the number

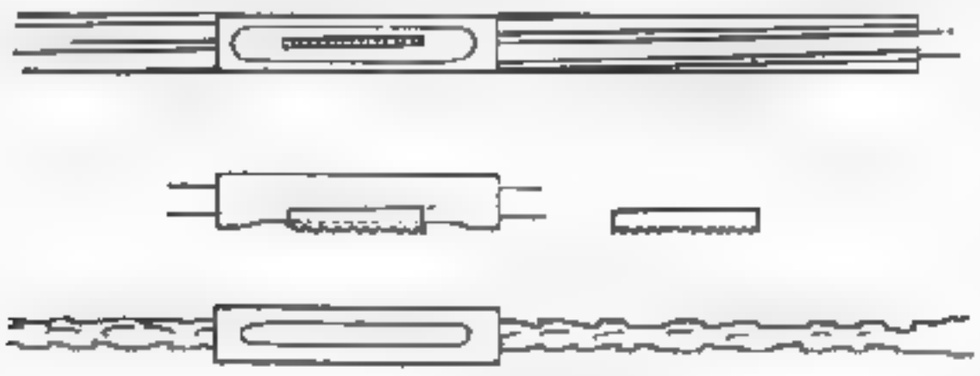

Fig. 208

of strokes made with it to deepen the groove the required amount. And be sure that you use the same number of strokes in each of the other grooves.

But to get back to this first groove we are working on. You can tell from the feel of the rod when the cutter is jumping over deeply pitted or corroded spots. The moment you get a full smooth cut, remove the entire head very carefully, after marking on muzzle of barrel the exact point at which the cutter came out. Inspect the groove you have been cutting, and if clean and smooth from one end to the other, stop working on it. If pits still show, and you think it will stand deepening a bit, replace the cutter carefully in the same groove, and continue a few more strokes. An extra thickness of the shimming should be used whenever the cutter stops taking hold.

Now remove all the shims and in like manner start in on the next groove. From now on you cut the exact number of cuts in every groove, regardless of whether all are properly cleaned up or not. When all grooves have been cut, if pits still show, select the groove having the deepest ones, and make a sufficient number of cuts in it to remove them, then a like number of additional cuts in all other grooves.

I should have mentioned that the better plan, when changing the cutter from one groove to another, is to melt off the old lap and cast a new one each time. This is not always necessary, but many old rifles do not have the grooves spaced evenly, and the new lap is advisable to avoid running the cutter against the side and widening the groove.

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Before you started cutting, you should have made a small sulphur cast of the bore at the muzzle, and measured the full groove diameter. Now make another cast and measure groove diameter after the cutting. The bore should now be enlarged a corresponding amount, more or less, so that the grooves may be about the same depth as they were originally.

A straight spiral reamer should be ground to about .0015 less than the final diameter required. This reamer should be six inches long if possible, and should be relieved for a distance of 1 1/2 inches to enter the bore smoothly. Wrap the reamer in soaking wet rags, and braze the shank firmly to a long steel rod almost the full diameter of the reamer. Attach a strong handle, and ream the bore carefully full length, using the soda water and lard oil cutting compound mentioned in Chapter 31. There is little space between reamer head and the large part of shank to receive the cuttings, so the reamer should be removed frequently and chips carefully brushed off. *Use plenty of cutting compound.* Be sure the reamer is not oversize for any point in the barrel, and if it stops do not try to force it. Remove it, and you may find a cutting or two jamming the cutting edge or clogging the grooves. Do not cut for more than an inch or so before removing the reamer and cleaning off the cuttings.

When you have reamed clear through the bore, wash out with boiling water and dry thoroughly. Cast a regular lap and lap the bore for as long as necessary to remove all cross marks from the lands, and give it a bright polish. Thus you have rebored and rifled a barrel without changing the original pitch or rifling, and very little special equipment has been used on the job. Before the final polishing you should check up on the bore diameter and its suitability for the ball you purpose using. It may be necessary to either find a new mold, or to lap the bore a trifle larger.

The reason for cutting the grooves before reaming the bore is that the old grooves provide a certain means of guiding the cutter for the new cuts; while reaming the bore might eliminate the grooves, leaving you with no cutter guide, if the reaming were done first. This method is entirely practical in old style barrels having very narrow grooves; but I would question its practicability in a barrel with wide grooves and narrow lands. Undoubtedly the lands would be damaged by the reamer. It will not work in a rifle with "gain" twist.

CLEANING OFF RUST. Having either cleaned, or re-cut the inside of barrel we next turn our attention to the outside. Often it will be encrusted with rust, and the original finish completely obliterated. If it is desired not to rebrown the barrel, try liberal applications of Hoppe's No. 9 followed by careful scraping with a scraper made of soft or half-hard brass, with edge filed square like a cabinet scraper. A piece of printer's brass rule is fine. This may be followed with a brass wire brush, using plenty of No. 9, which

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is the best rust solvent I know of. This treatment will leave a slight deposit of brass from brush and scraper, which is removed by vigorous rubbing with curled hair such as is used in stuffing up bolstery, or a piece of coarse woolen cloth, with plenty of oil. If the barrel smooths up nicely with a good deep brown color, very light buffing on a soft steel wire buffing brush will burnish it and improve the finish. Then heat the barrel by pouring boiling water over it until it is as hot as the water will make it. Dry quickly and rub with a woolen cloth and linseed oil. When cool, wipe off the oil and rub barrel lightly with a dry cloth.

This method of cleaning may also be used on lock plate, hammer, and other steel or iron parts.

If one is desirous of imparting a brand new finish to the entire arm it will be necessary to strike the barrel and polish barrel and all parts as described in Chapter 18, then reblue or rebrown. For old muzzle loaders the Zischang bluing solution mentioned in Chapter 20 is the best I know, as it gives a finish comparable to that used by the best makers of the old days. On soft iron barrels it will give a deep brown rather than blue or black, which is just what you want. Or you can follow the method of many of the backwoods gunsmiths, of rusting the barrel by repeated applications of pure, strong cider vinegar,—scratching off the rust each day and applying more vinegar until the color is as desired. A final boiling is necessary to stop the rust.

The breech plug should receive careful attention, as well as the threaded portion of barrel into which it screws. Scour the threads clean of rust with a stiff brush dipped in Hoppe's No. 9, wipe dry, and oil. The threads on breech plug may be cleaned by buffing on steel wire buffer. You are likely to find that the removal of rust has made the threads somewhat loose, so that the plug can be turned past its normal stopping point. The practice of the old gunsmith was to place a thin sheet lead washer between shoulder of plug and end of barrel, and tighten the plug up firmly against this washer, which was then trimmed down smoothly on the outer edges.

The flash-hole and pan of a flint-lock should be freed of rust by scraping with brass and careful brushing, using plenty of Hoppe's No. 9. Brass scrapers should be filed or ground to shapes that will reach into all curves and hollows. It is permissible to polish out the inside of pan and the bottom of frizzen which covers the priming with fine emery cloth, liberally oiled. Clean out the touch hole with brass wire, being careful not to enlarge it. If badly enlarged by rust, it will be necessary to drill the hole clean with a twist drill, and bush it. This is easily accomplished by reaming the hole to fit a standard taper pin. The pin should be annealed by heating red hot; then chuck it in the lathe and drill the touch hole usually about 1/16 inch diameter. Reharden the pin and drive it snugly into the reamed hole, then dress the upper end down flush with surface of

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pan. The dental engine and carborundum points mentioned in Chapter 4 will make a perfect job at this point.

Check over the lock mechanism carefully for broken or damaged parts. Soak the parts in Hoppe's No. 9, scour them with a steel wire brush, and if absolutely necessary, polish them with fine emery cloth and oil. In most cases the springs will not be badly rusted, their hardness and the fact that they were kept well oiled, having protected them somewhat. *Do not use a file on the springs.* Merely polish them clean. If a spring is broken, either make a new one exactly like the old one, or better still, obtain a genuine old spring of the same type. Many old gunsmiths and some collectors and dealers have large stocks of parts picked up in the course of their work. Mr. George L. Moore, Route 3, Rushville, Missouri, has a very large assortment of such parts, including cast brass and silver fittings, complete locks, set triggers, and old tools of all kinds. He has purchased the complete layout of tools and supplies from several old shops, whose owners have died long since, leaving their treasures to the tender mercies of unthinking heirs.

Sometimes THE MAKING OF MISSING PARTS which cannot be secured by any other means, involves a job or work that will stump the best mechanic. The filing out of a flintlock "cock" is a piece of file sculpture calling for perseverence and ability; and the harum-scarum chap who is inclined to become impatient, should keep in mind a picture of the backwoods gunsmith with his crude home-made tools, whose skill and patience enabled him to produce the entire gun with much less efficient equipment than is possessed by the average amateur.

The replacement of damaged screws can sometimes be accomplished by the use of standard machine screws. More often, however, it will be found necessary to have some of them made on a lathe, in which case the size and shape of the original screw should be faithfully followed.

Often there will be found some small broken part in the mechanism of an old gun which it is not intended to put into shooting condition. In such instances it is usually best to repair and use the original part. The average jeweler is well equipped to hard-solder such small parts as the cylinder hand in an old revolver, for example, and such work had best be entrusted to him if you are not certain of your own ability to turn out a good job.

Brass trigger guards, brass or silver inlays and other decorative pieces should be handled judiciously. They often acquire, through age and from atmospheric surface oxidation, a rich, dark "patina" that is much admired by collectors; and this appearance of age will surely be destroyed by polishing the surface. If gummed and dirty, try first washing the metal with a little ivory or castile soap suds on a rag wrapped around the fingertip. If the gummy coating persists, scour it off carefully with rottenstone and linseed oil. The

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reason for using linseed instead of a thin oil is that it will not damage the wood around the parts. After cleaning, wipe the remaining oil off with a soft cloth, then rub with a soft chamois.

One should enter advisedly upon the cleaning up or REFINISHING OF AN OLD STOCK. Like various metals, wood also acquires a rich dark "patina" with age and use; and its appearance is far more appropriate on an antique arm than a finish that looks like it might have been done yesterday would be. Quite likely the stock will be badly gummed with dirt and grease. It is often a good plan to carefully wash the surface with a rich white soap lather on a rag; do not have the rag dripping, but have the lather thick, and do not rub too hard or too long. Rinse out the rag in clean water, wring it nearly dry, and wash off the soap immediately. Dry with a soft clean cloth. This washing must be done very quickly, so that no water may soak into the wood. Then hold the stock near a blaze for a few moments to remove any remaining moisture, but do not get it hot.

If this leaves a coating on the stock, or if it fails to bring out the original finish, dip a small wad of cloth in linseed oil, coat it with the finest powdered pumice, and rub lightly until all accumulated dirt and gum have disappeared. Wipe off the oil and pumice, then go over it with linseed oil only; wipe this off entirely dry. Then mix: White shellac in alcohol, 1 part; raw linseed oil, 1 1/2 parts; light gun oil, 1 part; color if desired with alcanet root or oil soluble red; add two teaspoons turpentine and 1 teaspoon acetone to one pint of the mixture. Shake well, and apply a very small quantity with a wad of soft cloth, rubbing briskly, and taking a clean place on the cloth as it becomes dirty It is surprising what a quantity of dirt this mixture will remove after you think the stock is clean. Rub fast and there will be no sticking or gumming tendency; the oil in the mixture will leave a light moist coating, which should be rubbed in with the bare hands (wash the hands first), then polished dry with soft woolen cloth.

There are few stocks that are improved by complete refinishing—this cleaning up process removing the dirt and gum, and actually deepening the rich tones that have come with age, without impairing the finish in the least. On a stock that is in very bad shape, use the finest steel wool obtainable, and have it well oiled with a thin gun oil. If done carefully and lightly, this will not injure the old finish. Complete the job with the above described mixture.

OLD PERCUSSION GUNS are usually of less value in a collection than flintlocks; one may be warranted in making more changes to put them in shooting condition. New tubes or nipples are nearly always needed, and these can be obtained from gunsmiths, or from Schoverling, Daly and Gales, New York City; Gus Habich, Indianapolis, Ind.; or Geo. L. Moore, Rushville, Mo. Old percussion hammers are often "burned" and corroded on one side where they

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strike the cap, and when in this condition they should be replaced if possible.

BROKEN STOCKS. Old stocks that are badly damaged can often be repaired almost good as new; in some instances the repair being nearly invisible. The first thing to do is to place the stock in a tight closet with two formaldehyde candles (obtainable from most drug stores) and allow the candles to burn until all consumed. Do not open the closet for 24 hours. The fumes will kill off any worms, borers or other insects that may be in the wood, and will not damage the silver or brass inlays, if any. Worm holes should be filled with small walnut or maple pins whittled to fit, and set in du Pont Cement, then filed off smooth with a very fine file, and the place polished over.

A stock that is broken or split at the grip should, if the break extends deep, be broken entirely in two, then cemented with du Pont cement and firmly clamped for several days until dry. Be sure the clamp or vise is well padded to prevent marring the wood. If the shape is such that it cannot be clamped, bind it firmly with wet green rawhide, which in shrinking will hold as tightly as a vise. When using rawhide, first cover the stock with a layer of adhesive tape so the moisture from the rawhide will not damage the finish. Or, the stock may be coated with a thick layer of rubber cement which after drying will protect the finish. . The layer of cement peels right off later.

Sometimes it is possible to use one or more screws in the stock, as described in Chapter 14.

Where the wood is nicked or chipped or has pieces broken out and missing, it is necessary to inlay similar wood. Building up with Plastic Wood is not advised, as it will not match the stock so well Pieces of scrap walnut or maple, or whatever wood the stock is made of should first be aged to match the stock as well as possible. Rig up a small box with a tight fitting lid, and seal all cracks with strips of paper or tape. Put the wood scraps in the box, with a small bowl of stronger ammonia (26 to 28 per cent gas) and leave for several hours until the fumes have aged and darkened the wood. Another way is to make up a small quantity of Zischang bluing solution (Formula No. 5, Chapter 20), and while the wire nails are dissolving in the two acids, place the wood pieces in a wire basket and hang them in the top of the mixing jar, where the thick vapors from the mixture will surround them. When darkened sufficiently, wash the wood thoroughly in clean water, and let dry several days before using. The patches or inlays should be cut almost to size and shape before this artificial "aging" as the color may penetrate only a little way below the surface. Sulphuric, Nitric, Hydrochloric and various other acids, both straight and in solution, may sometimes give just the color desired. They should be used quickly, however, and washed off thoroughly when the color or shade desired is obtained.

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Ferric oxide, or red iron rust, dissovled in a little ammonia, and painted on often proves to be just the ticket.

Fit the patches or inlays carefully, using a sharp file to shape

the edges, and bring them to as tight a fit as possible. Any rotted or splintered wood must of course be cut out of the old stock, and the patch shaped to fit. Cement with du Pont cement, and clamp or bind until dry. Finish the patch to shape by filing with a fine file, then polish with finest sandpaper, then crocus cloth. Get as high a polish as possible on the bare wood. Then take a scrap from the same piece used in the patch, and oil it with boiled linseed oil. Compare the color with the old stock. Chances are it will be much lighter. Let the oil soak in over night and again compare it. This test should be made before you attempt to finish the patch. If the oil on the sample piece does not darken it sufficiently, it may be necessary to stain the patch. Use Johnson's Wood Dye or Ad-El-Ite Stain—and try it on a scrap before risking the patch. After the patch is the right color and the stain has dried for a least a day, rub over the patch with: orange shellac in alcohol, 4 parts; boiled linseed oil, 1 part; spirits turpentine, 1 part; spar varnish, 1 part. Rub fast, and immediately wipe off all surplus and rub with bare hand. If the spot shows up light, darken the mixture with alcanet, oil soluble red, burnt umber or any other suitable coloring, and repeat application until the color is right. Let dry, and polish the whole stock, after which the patch will scarcely show at all.

The foregoing contains, I believe, all the essentials for cleaning up almost any antique firearm and putting it, if not into shooting condition, at least into shape to present the best possible appearance in a collection. There is no occasion for relining of barrels on such pieces, nor for more extensive alterations which would cause the gun to lose its identity. Old shotguns with barrels badly rusted had best be left with merely a careful cleaning, as lapping or polishing out the bore is likely to make the barrel walls so thin as to run toward the danger point. These old shotgun barrels were thin enough in the first place.

IN CLEANING UP OLD STOCKS, under no circumstances should colored varnish of any description be used. This sort of work is the mark of the rankest amateur who neither knows nor appreciates the gun's value, nor the beauty of original finish. All he is after is the "shine"—and he probably considers the finish of a new John Deere plow as superior to the finest gun in the world.

Sometimes one will pick up a fine old gun on which the stock has been covered with shellac, colored varnish, or even paint, concealing a piece of wood of rare beauty. Such a coating should be carefully removed as follows: Use either a standard paint remover, or mix 3 parts acetone with 2 parts grain alcohol; spread this on a small spot about as big as your hand, and leave for a few minutes

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until the finish softens, then scrape it off carefully with a blunt edged table knife, and immediately wipe off the remover. Take another spot in the same manner and continue until all this coating is off, then go after the small streaks and spots that remain. Using the remover in this manner will not seriously affect the original finish, whereas if used according to instructions and the entire stock well soaked with remover, the finish underneath will likely be ruined. After this cleaning, wash the stock lightly with white soap-suds, then with clean water, dry thoroughly and finish as described.

Speaking of painted stocks—I believe the maddest gentleman I ever saw was a collector friend of mine, to whom an old lady down in the Ozarks had promised a fine old spinning wheel that had been stored in the attic for half a century. On his return a week later to get it, he found that in her eagerness to please him, she had given it a lovely coat of pea-green enamel, with gilded rings on the legs, and a basket of flowers "transferred" on the side of the wheel! This party was still cussing roundly as he drove into town with his "new" spinning wheel some six hours later, and who can blame him? The idiot who will perpetrate such an outrage on an old gun undoubtedly deserves no less than hanging, and if drawn and quartered into the bargain he will get no more than his just deserts!

Often an old muzzle loader will be found with RAMROD, THIMBLES, AND RAMROD SOCKET missing. The new ramrod, if a genuinely old one cannot be found, should be planed nearly to size from a straight-grained split of white hickory, then scraped to final size with broken glass, sanded, and finally polished with pumice stone on a rough cloth. Then it may be darkened with ammonia, and some orange shellac, with 10 per cent. of linseed oil added, rubbed in with a rag. Work fast, and with long strokes, and the rag will not stick, and the shellac will be dry before you stop rubbing.

Thimbles are made by bending sheet brass around a steel rod as shown in Figure 209; the turned out edges are trimmed down narrow, their surfaces carefully tinned, and sweated to the barrel. Sometimes sheet silver is used, or German silver. Ordinary soft solder may be used in either case, but a good jeweler's medium hard solder will be found superior. The spot on underside of barrel where the thimbles are to be soldered must of course be scraped bright. Very good thimbles may also be made by cutting a short piece of thin brass tubing of the proper size, flattening it slightly on one side, and soldering to the barrel. When the wood of the stock extends clear to the muzzle, the thimbles should be bent from sheet metal as first described, the lips or wings being left sufficiently long to insert through a slot cut in forend. They are then spread back on both sides, and countersunk their full thickness into the wood, the pressure of the barrel holding them firmly in position.

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The socket or tip on the forend into which the ramrod is inserted is usually a brass, silver or German silver casting. If such a tip cannot be had from one of the dealers already mentioned, a pattern may be carved from soft pine and sent to a brass foundry; or if one has a forge or other suitable means of heat, he may make his own casting, using a mold of fine sand, stiff clay, or plaster of Paris. The casting is then filed to shape and size drilled, polished, and finished to the color desired (See Chapter 20). A butt plate can be cast in the same manner as well as a trigger guard. I have seen a number of these parts in Mr. Moore's collection which show that they are crude sand castings, made in the smith's forge.

Fig. 209

Fig. 210

The tip of the forend at muzzle was usually covered with a lead cap in the older guns. If missing, this lead piece is easily replaced. Sometimes the wood will be damaged or broken at this point, in which event an inch or so may be cut off and a new tip cast in place. The wood should be shaped up into a tenon, and the tenon undercut as shown in Figure 210. Then wrap barrel and forend with stiff strong paper, letting the paper wrapping extend an inch or so above the muzzle. Spread a layer of soft clay or plaster of Paris over the outside of paper, and pour in a sufficient quantity of melted lead to fill the space between paper and underside of barrel, completely covering the end of wood tenon. Remove the paper, and file the lead smoothly to shape.

RE-CONDITIONING ACCOUTREMENTS. Often the fortunate collector will find with an old gun the powder-horn or flask, leather hunting bag containing mold, pick and other implements. In other instances he will be able to assemble these things by picking them up from various sources. They too should be carefully gone over and cleaned and reconditioned, with due regard to their natural deterioration after years of disuse.

The powder horn may show cracks; if not bad, let them alone. Sometimes it is possible to force a little du Pont cement into the cracks, joining the edges firmly. Clean the horn by washing in white soap suds (cold), same as you did the stock. With toothpicks clean out the accumulation of dirt in the engraving or carving, if any. Polish the horn with fine powdered pumice rubbed on with the palm of the hand; wipe off with a damp cloth and polish dry; then rub briskly with the hand with a very little neat's foot oil, which will relieve the brittleness.

The mold, pick and other small items should be cleaned free from rust, but complete polishing had best be omitted. If desired to use the mold for casting bullets, soak it a few days in Hoppe's No. 9, and scour the inside with a brass wire brush. If badly rusted, cut a 3 inch piece of drill rod, file one end rough and jagged, insert it partway into the mold with the screw-cutter turned to one side, and cast a bullet around it. With this as a lap, the other end of rod being held in the breast drill, you can easily lap out the inside

of mold to a good smooth surface, although this will of course enlarge it slightly. Use fine valve grinding compound for the first lapping, then cast a second lap and finish with the finest emery flour and oil.

The old leather hunting bag will doubtless be hard and brittle, both the bag and strap ready to break if the leather is bent or folded. Empty bag carefully and clean out all dust and litter, then immerse it for three or four hours in a pan of warm (not hot) water. Shoot a couple of squirrels or other small animals and put their brains in a cheese cloth bag; stir this in the water and squeeze out the brains until the mixture is milky. As soon as the leather begins to soften, work it gently in the hands, always under water, until soft and pliable. Then remove from the water and dry slowly, away from artificial heat, working it in the hands occasionally while drying, to prevent hardening. When nearly dry, apply neat's foot oil liberally, working it clear through the leather. Let stand a few hours then wipe off surplus oil. Wring and work the leather, wiping off oil as it comes to the surface, until it is as dry as you can make it. After a few days, clean with English saddle soap, which will give a good surface appearance and make the leather nearly like new. It is astonishing how much of the original strength can thus be restored to old leather that is ready to break and fall apart due to drying out of the fibres.

This method of using brains in dressing leather is one that was often employed as a tanning process by the backwoodsmen of a century or more ago, resulting in a very soft, tough, flexible leather. If squirrels are out of season, and the neighbor's tomcat crawls under the house, try a few hog brains from the butcher shop.

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CHAPTER 34

EMERGENCY AND FIELD REPAIRS

THE man who has the misfortune to break or damage his rifle in the middle of his trip is in a bad way, as a rule. Unless the damage is such as can be repaired in the field, and unless he has at hand a few emergency tools and repairs, the hunt is over for him right there and then. The repair need not be of a permanent character, but it must be such as will enable him to use the gun for the balance of the trip. With this in mind, the thinking sportsman, unless he is able to afford and carry along more than one gun, will be sure to include in his duffle a few tools and materials for use in such an emergency.

Just how much of a repair kit can be carried depends on the length and nature of the hunt. The man out for only a few days and "going light" must cut the list down to fundamentals. If the trip is to last a month or longer, and if there are several in the party, with packhorses or burros or other suitable means of transportation, then it will pay to include a small but rather complete tool chest.

The individual who hunts alone, or with only a guide or friend, and packs his own equipment, will find the following equal to most emergencies, and requiring minimum space.

1 Starrett Combination hand vise No. 16, with clamp. This may be converted into a small bench vise, and clamped onto a fence, a board or other convenient place.
1 Starrett No. 142 B pin vise.
1 8 inch flat mill file, 1 6 inch 3-square file.
1 6 inch side cutting pliers.
3 or 4 short pieces of small drill rod in sizes needed for pins, etc.
1 small hammer, 2 hacksaw blades, 8 inch.
1 large short-handled screwdriver, 2 or 3 small screwdrivers.
1 small roll acid-core wire solder, 1 small radio soldering copper handle cut off.
1 small roll 24 ga. copper wire, 1 small box assorted brass wood screws.
1 stick prepared glue.
1 10 yard roll 2 inch surgeon's adhesive tape.
3 ft. length rubber tubing with metal tube in end.
Spare parts, such as springs, sights, strikers, extractors, etc.
1 good strong pocket knife.

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This may sound like quite a list of stuff—but it will pack into a space no larger than your lunch or camera, and weigh only a couple of pounds or so. The combination hand vise is almost essential if you have a really serious repair to make on a sight, or any filing of parts to do. The pin vise enables you to make any size drift punch needed by merely cutting off a short length of drill rod and setting it in the chuck. The hammer should be very small—a four or five ounce ball peen machinist's hammer with handle cut to 6 or 8 inches; for heavier hammer work, use the small axe which is a part of your regular equipment. The screwdrivers should be selected according to the size screws used in your gun. The hacksaw blades may prove essential—they can be used without the frame as one uses files for small repair work, and take up practically no room. The soldering copper should be the small one sold in ten-cent stores, and the handle cut off leaving the total length about 6 inches. The shank should be sharpened. Then it is easy to whittle a handle from a piece of green wood, drive it on, and discard the handle when through using it.

The rubber tubing, into the end of which is fitted a 6 or 8 inch length of light brass tube, makes a forge of your open campfire—just get a good bed of coals between some rocks, insert the metal tube into base of fire, and blow through the rubber tube. The soldering copper is quickly heated for use. This is also a good stunt for starting a campfire when the fuel is damp and the fire cranky.

Prepared stick glue is made as follows: Take a quantity of white flake glue and cover with cold water. Let soak over night in the gluepot, then heat until it is simmering slowly, but not boiling hard. Let simmer until it has the consistency of thick cream. Roll tubes of parafined paper about 3/4 inch in diameter, pour in the glue, and let it set. A tablespoonful of glycerine added to the glue and well mixed just before pouring will improve it. About 4 inches is a handy length to make the sticks.

To use this glue, as for instance in repairing a broken stock, first warm the broken ends of the wood; peel the paper from the stick of glue for about an inch; heat this end by dipping in boiling water, or holding in a clear flame until it runs like sealing wax; rub it quickly on the wood, and bring the two ends firmly together, holding them until cool.

A stock broken through at the grip is a common accident, and a very disconcerting one also. Yet such a break can in most cases be repaired in the field to give good service, although the appearance will of course suffer.

The nature of the repair will depend on the break. If nearly square, some sort of dowel or pin is almost essential. Colonel Whelen described a repair which he made by filing a large nail to a point at each end, drilling holes for it in each broken end of the stock, and forcing the nail into these holes as a dowel. In some

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instances it will be found very difficult to line up the holes so that the broken ends will come tightly together, and at the correct angle. The best way is to first make the hole in one piece, blacken the spot around the hole with soot, and press the two parts together. This will then show where to drill the hole in the other piece.

I included no drills in my list of emergency tools, for the reason that any sort of hand drill or breast drill is too heavy and large to go conveniently in the "go light" pack; of course it should be in the kit of the larger party out for a long trip.

Small drills for wood are easily made by filing a piece of drill rod flat and pointing it. Hold it in the pin vise while using. Larger holes may be burned, using a nail somewhat smaller than the hole required.

Another method of repairing a broken stock which Whelen describes is to break off a couple of table knife blades and inlay them into the sides of stock across the break, after which they are wrapped with fishline, wire, tape or what have you. But since the average lone hunter is quite likely to have no table knives in his outfit, it might be a good idea to prepare in advance two strips of brass about 1/16 x 5/8 inch and about 5 inches long; drill three or four holes for screws and countersink them deeply for the heads. Should such a break occur—as it probably never will if you have the wherewithall to repair it—inlay these strips across the break; glue the ends together as already described, set in the strips, set short brass screws in tight, and wrap the whole business with adhesive tape. Better still, wrap it with copper wire, and coat the wire with solder as described in Chapter 14.

A split or shattered forend is easily repaired by wrapping tightly with adhesive tape or with windings of copper wire well soldered.

The efficacy of green rawhide is well known in making temporary or even permanent stock repairs—but how in thunder are you going to shoot a critter for his hide if the gun is out of commission? It develops into the old question of which came first, the chicken or the egg?—unless you have been fortunate enough to kill some-

thing before breaking the stock—or unless you can sneak up close enough to the animule to beat it to death with your gun barrel. Anyhow, assuming you have found a way to procure a hide—for example that of a muley cow that wandered away from the home pasture and kindly permitted you to knife her—soak the said hide in warm water and wood ashes from your campfire until the hair will slip. Scrape it smooth on both sides and cut into strips. Wipe the strip fairly dry and bind around the break, stretching the rawhide as tightly as possible. In drying it will shrink until you could almost drive fence posts with the stock if necessary. This makes a good repair for a stock having a long diagonal break. The break should be glued before winding on the rawhide. Adhesive tape or copper wire will do about as good a job as the rawhide.

Getting things stuck in the barrel is a well known source of annoyance and danger. If any accident occurs, such as falling off a horse, or sliding down a gully, make it a point to unload your gun immediately and peek through the bore. Likely as not it will be plugged with mud, sand gravel, leaves, twigs, snow or other impedimenta, the immediate and complete removal of which should be your first concern. Otherwise, the searching party sent after you a month or so later when you fail to return on schedule, may have the pleasure of carting back your well picked bones in a market basket.

A good strong steel cleaning rod should be a part of every hunter's equipment, for which reason it was not mentioned in the list of emergency tools. It is as necessary as the rifle itself. Personally I have no use for those rods made in 6 inch joints. In theory they are fine; in practice, not so good. I never saw one yet that was so accurately machined that it would joint up straight—squinting down it reminds one of the old stake-and-rider fences once so popular in our rural districts. Such a rod tucked snugly into a trap in the butt, adds something like a pound to the weight of that end of the rifle, throwing it badly out of balance and making it feel as though the barrel had been left at home. A rod with 12 inch joints is stronger, straighter, and takes up mighty little room in the pack; and a pull-through in the butt weighs nothing to speak of, and gives one a legitimate excuse for that six dollar, trapped buttplate.

With such a rod it is easy to poke obstructions from the bore after which the barrel must be thoroughly cleaned with oiled patches.

Sometimes in the woods one will get a cleaning rag or patch stuck in the bore. If this cannot be removed by soaking with oil and warming the barrel as described elsewhere it can be picked out, with a screw tip on the cleaning rod. This tip is just a 3 inch length of drill rod a little larger than the cleaning rod—it should be nearly bore size. On the end of tip is brazed a 2 inch wood screw with very coarse thread. The overhanging edge of screw head is then ground or turned off even with the rod. Turning this into the rag and yanking will remove it bit by bit. Such a tip should be a part of the regular cleaning rod equipment.

Sometimes when away from camp one will have recourse to an improvised cleaning rod made from a sprout—and more often than not the stick may break off and lodge in the barrel. The safe plan is to go back to camp and get the steel rod and push it out. I am not recommending that anyone do otherwise. But—in a similar emergency I have *shot* the obstruction out, after first prying the bullet from the cartridge and throwing it away, along with about half the powder. I advise no one to follow this method; but as I say I have used it, and the rifle showed no ill effects

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whatsoever, the bore measuring the same afterward as it did before. I *believe* this to be perfectly safe, even with the full powder charge of a .30-06, because of the greatly increased air space which extended several inches up the barrel, after the bullet was removed, to the point where the rod was stuck. But half a charge removed it, so why take chances?

Nothing puts a rifle out of the game more quickly than a broken, bent or otherwise damaged sight, either front or rear; and many are the methods employed by ingenious hunters in such an emergency. The thoughtful pessimist will of course carry along one or two spare sights—either in his kit, or in a recess in butt, or under the pistol grip cap, some types of caps having a small well provided for this purpose. With the Springfield, or any rifle having sight base on the barrel into which the sight is pinned, it is advisable to discard the pin and ream and tap the hole for a 2-56 machine screw—and carry along a few extra screws as well as sights. Then the sight can be changed when and if necessary by merely turning out the screw. If held by a pin, however, and the pin drops out as they will occasionally, make a new pin from a piece of drill rod, and drive it in with the new sight.

If the front sight becomes lost and you have no spare one, there are lots of things you may do before deciding to call off the trip. Most any old scrap of iron will do for material from which a new sight may be filed out; and you'll be thankful for the vise when this occurs. A sight may be cut from tin, brass, or filed from a copper or silver coin, and soldered to the barrel. Rather than nothing at all, one may build up a lump of solder on the barrel and file it to shape afterward—and if you are careful to avoid knocking it against things it will last out the trip. I've seen a mighty good emergency sight made by building up a solder base, and setting a small brad in the top of it for a bead. And I've seen a good one carved out with a pocket knife from a piece of leg bone of a deer.

I hope I may live to see the day when we will have a peep sight as strong as the balance of the rifle—the sight is at present one of the weakest parts. Dropping the rifle on the sight will nearly always put the latter out of commission. Because of this I like to have a Lyman No. 6 or similar folding leaf sight on the barrel; it serves the dual purpose of enabling me to check up on the aperture should anything happen to the gun, and of providing a dependable rear sight if the aperture is damaged so that it has to be removed.

The man without such an emergency sight to fall back on, however, need not be disheartened to the point of dropping his gun over the nearest cliff and jumping over after it. There are several things possible before deciding on such a step. About the easiest and quickest is to first open a can of beans or sardines, and eat the beans or sardines as the case may be. Then cut a piece of tin

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from the can approximately the width of the average rear sight. Bend it at right angles and solder it to the barrel four or five inches from receiver. A few shots looking at the front sight over this should give you the elevation. If the tin is only a little too high, bend it back slightly to lower it, rather than cutting it down. When you have the elevation, run some solder in behind it to make it fairly rigid. Now locate the place for your notch by firing a few shots by sighting over different points on the edge of this tin, and when you think you have the right point located, file the shallowest possible notch and try it. It may be necessary to try two or three places, before the gun will shoot accurately enough to give you a fair chance with it. When sure it is right, file the notch to required depth, and file out the shallow test notches. If this makes the sight too low—bend up a little.

Now there's nothing to prevent using such a flimsy affair during the remainder of the hunt, if you handle it carefully; or, there's nothing to prevent making a stronger sight from a coin, piece of brass or iron, and soldering it close to this tin one, after filing it to the same height, and then removing the tin. Soft solder has a lot of strength if you first scrape the metal bright and put on plenty of solder at good heat.

If the barrel happens to have a rear sight alot, your task is easier. File a sight from metal, bone, horn, or anything you have—even a piece of hard wood—and drive it in; then file down to correct height and cut the notch.

I saw a front sight in which the gold bead had dropped out repaired as follows: The hole where the bead had been was filled with a drop of solder. The soldering copper was held against it to keep the solder molten, while a pinch of filings from the soldering copper was dropped onto the solder—and they stuck. A tiny piece cut from copper wire would have been as good—probably better—and could have been set in solder in the same manner.

I read a description in one of the outdoor magazines of a method one man used to replace the stem from a tang peep sight, the original stem having been damaged or lost. He cut off the head of a common safety pin, bent the two legs together and forced them into the sleeve of the sight. The loop of the bottom end formed the aperture which he reduced in size and made show up more clearly

by winding through the loop with fish line or thread. Doubtless the party who originated this idea was a father.

Another very good substitute for a peep sight is to twist a short piece of copper wire into a small eye or ring, spread the ends, and solder them to receiver bridge or other suitable place. This aperture may be bent up or down, right or left as needed to sight in the gun, after which additional solder around the base will stiffen it enough to give good service if you are careful.

There are few action parts of the modern firearms liable to

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damage through ordinary use. Firing pins or strikers sometimes break, and I have heard of their being filed out of a nail, but never saw it done. The safe plan is to carry spares for all parts likely to break, including a spare extractor. The recess under the trap butt plate is as good a place as any to carry them. An extra screw or two, duplicates of screws likely to have to be removed in the woods, should also be carried in case you "jim" the head of one in removing it.

The target shooter who plans to attend the National Matches, or who goes in for competition to any extent, should, if he is able to do his own repair work, take along a small compact kit of tools and a few spare parts. While at the larger matches there is usually an armorer or gunsmith on the ground to handle emergency work, the real crank has a bit more confidence in his own work than he has in anyone else's. And he will probably be more careful, also, about marring the gun in the process—at least, he thinks he is more careful. A steel fishing tackle box of the right size makes a splendid repair kit container. I believe the Company Repair Kits mentioned by Colonel Whelen are no longer available. At all events, the large hunting party, or the small party out for an extended trip, and the target shooter at an important match,—all are likely to find a rather complete kit well worth the trouble of assembling and carrying along.

The selection of tools which it contains will depend largely on the individual, and the needs which he anticipates. The same tools used on the home workbench may be used, although if one makes frequent trips it will pay to duplicate the tools needed, and avoid the likelihood of having some tool at home when you need it in the field or on the range. One thing that should not be overlooked is the small screwdrivers, for sight screws—and an extra supply of screws also, for one will lose out occasionally, or the threads will wear from long use, making a tiny screw perhaps stand between the shooter and first prize—whether it be a loving cup or ten point buck.

One thing I have neglected to mention that may well be included in the field repair kit, is a small can of New Method Gun Bluer. When putting on temporary sights of tin, solder, etc., this lacquer offers a ready means of blackening them—is, in fact, about the only convenient means of doing so in the field. No need to carry a brush—use a match, twig, piece of paper, leaf or cloth.

One thing I have always carried and never have needed, is a broken shell extractor. If the head breaks off a .30-06 or other modern high power cartridge, the action is pretty apt to let go with far reaching results that will make the shooter forget about trivial matters for the time being. But in the cheerful hope that if it ever happened to me there might be no untoward results (whatever untoward may mean) I faithfully tote the old extractor, and hope to gosh I never have to use it.

HANDLOADER'S MANUAL

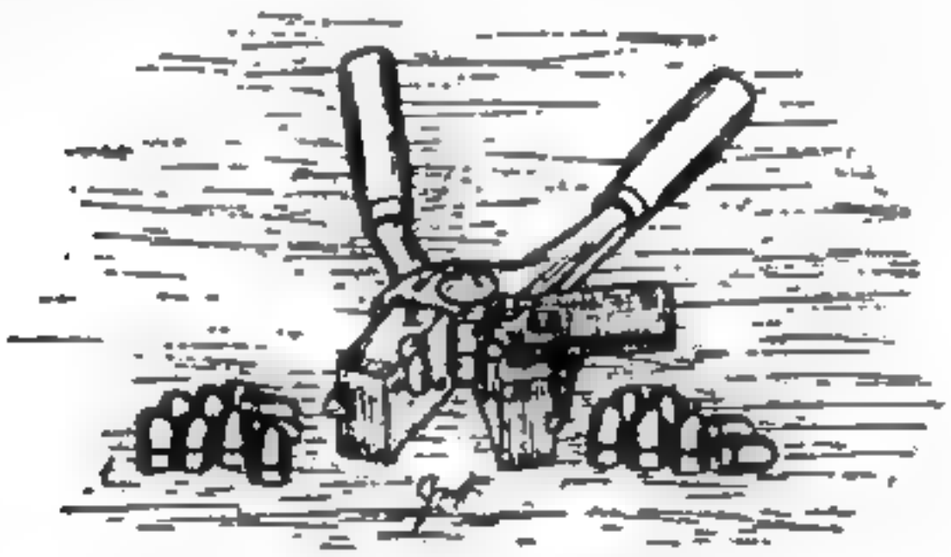
A Treatise on Modern Cartridge Components
and their Assembly by the Individual
Shooter into accurate Ammunition
to best suit his various
purposes

By

EARL NARAMORE

Major, Ordnance Department Reserve
The Army of the United States

Sketches by LT. COL. JULIAN S. HATCHER



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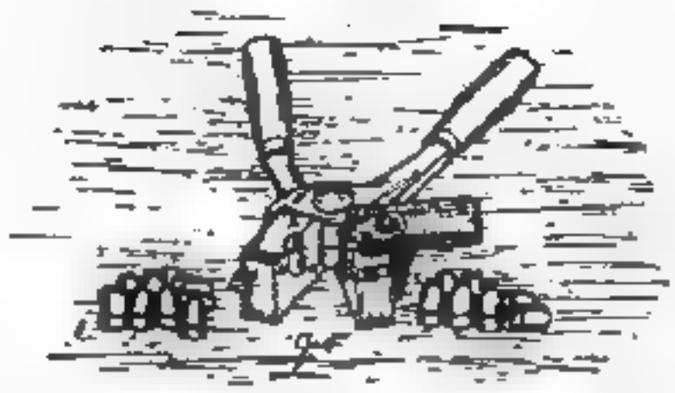

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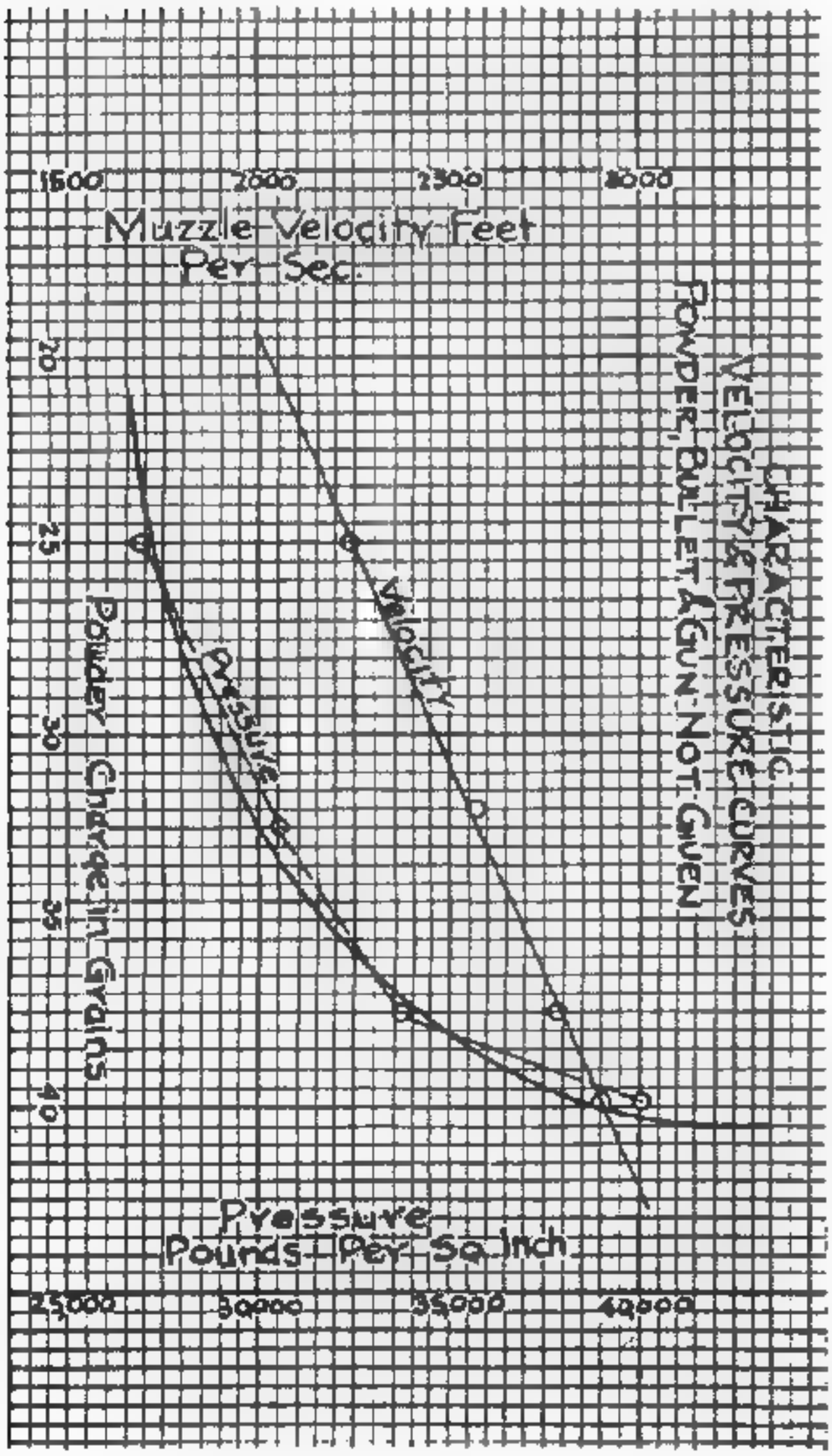

The frontispiece illustrates a characteristic velocity and pressure curve plotted for different charges as explained on pages 128 and 130. This is a typical curve and does not represent figures published anywhere or for any definite rifle, cartridge or bullet. It is seen that the velocity curve is virtually a straight line, thus showing that as the powder charge is increased the velocity is raised in a proportional amount. This means, therefore, that within the limits of the powder charges published, it is entirely feasible to estimate the velocity of any other powder charge by direct proportions as explained on page 126.

It is seen also that the pressure increase is not a straight line, nor is it in direct proportion to the powder charge used. The amount of curvature of the pressure line depends largely on the characteristics of the cartridge and the particular powder used. The quicker burning powders intended primarily for reduced loads or mid-range work will show a sharper pressure rise for a given charge increase than will the larger grain, slower burning powders. Consequently, for such faster burning powders, the maximum pressure level, safe to use, is lower than normal for the full load of slower burning powders usually for maximum loads. At low pressure levels, i. e., when using reduced charges, practically all powders will show relatively small pressure increases in proportion to the increase in charge. However, at or near the maximum charges published for a given powder in any cartridge, the pressure increases at a very rapid rate and out of all proportion to a unit increase in powder charges as illustrated by the sharp upward turn of the curve at its upper end. This characteristic pressure curve illustrates that between the charges published for any powder, it is perfectly safe to interpellate or calculate the pressure developed for any intermediate charge by direct proportion which would, of course, be the same as if the pressure values were read off the dotted straight line connecting two adjacent plotted points. This curve also illustrates that it is dangerous to attempt to estimate the pressures developed by extrapolation or extending the pressure curve beyond the maximum charges published for use with a powder. A few grains more powder, or under some circumstances, even a slight increase over the maximum charge may develop infinite pressure.

The published powder charges and ballistics obtained represent actual tests made with present day components. Many reloaders seem to go on the theory that the powder charges published are actually cut or lowered a grain or two for the ballistics shown and, therefore, they will play smart and deliberately increase the charge to offset this modesty on the manufacturer's part. For intermediate or low pressure loads it is seen that this can do no harm in the way of developing dangerous pressures, BUT for full charges or maximum powder charges published, such a mistaken idea may very well result in excessive pressures with resulting damage to the gun and possible injury to the shooter.

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Handloader's Manual

FOREWORD

THE BASIC ELEMENTS OF HANDLOADING.

The reasons for handloading ammunition may be summed up as (a) permitting one to obtain the greatest possible accuracy from his rifle, pistol or revolver and (b) providing one with an abundance of ammunition at small expense. If you have a firearm that you do not shoot as much as you would like to because of the expense, it will pay you to reload your fired cartridge cases.

Handloading is not a complicated procedure, nor does it require a large investment in loading tools. Any person of ordinary intelligence can, with a few simple tools and the instructions supplied by their manufacturer, load accurate and safe ammunition. Handloading is not recommended for the inmates of insane asylums nor for those who *should* be in such an institution.

The novice sometimes has the false impression that an extensive knowledge of ballistics is necessary in order to load good ammunition. This is perhaps fostered by reading books on handloading which contain a great deal of data that is of interest and use to the *experimenter* or to the person who wants to know "why," but it is by no means necessary to the man who merely wishes to reload good ammunition. To the reader who may have difficulty in separating the essentials from the non-essentials let it be stated here that reloading consists of replacing a fired primer with a new one and loading a proper powder charge and bullet into the case. One may be able to discourse for hours on all the subjects relating to the loading of ammunition but when it comes to actually reloading a cartridge he pokes out the fired primer and puts in a new one, loads a powder charge into the case and seats a new bullet—for that is about all any one *can* do.

Of course, there are a few details which must be observed in assembling ammunition in order to obtain the best of accuracy, but they are very simple things and it is no more *work* to load a good cartridge than a *poor* one.

While economy is the motive that prompts most shooters to reload their fired cases, it is obvious that reloading would not be practical unless the resultant ammunition were of good accuracy. Indeed, the superiority of carefully handloaded ammunition has long been recognized. In justice to the manufacturer, it may be stated here that it is not uncommon for some lots of factory ammunition to be fully as accurate as anything the handloader can produce. However, when match ammunition is produced, especially for long range shooting, the ammunition manufacturers practically hand load it. This is a slow and expensive procedure and such ammunition is often sold at a loss, the manufacturer depending largely upon the advertising benefits for his compensation.

To the person who knows nothing of handloading it may appear strange than an individual shooter without extensive knowledge of ammunition and with only a few simple and inexpensive tools can improve on the product of the manufacturer who has every facility at his disposal. The answer to this is not difficult. The very slowness with which handloading is done permits a minute 100% inspection of each and every operation by the person who has the most intimate personal interest in the result. Furthermore, the reloader can fit his ammunition perfectly to his own particular firearm. When ammunition is reloaded in large quantities by machine, the resultant product is no better than the average of new factory ammunition and is sometimes not as good. *Care* in handloading is of far more importance than *speed*, and the shooter who constantly bears this in mind will be rewarded by the superior accuracy of his ammunition.

Loading Tools.

The first requirement for handloading ammunition is a loading tool and such additional accessories that may be necessary to the purpose. It is not the purpose of this book to catalogue in detail all of the loading tools that are on the market nor to analyze or criticise any of them. Any attempt to do this is very likely to result in comments that are prejudical to one or another of them, as they are all combination tools and compromises are necessary in order to make them perform all of the necessary operations and to produce them at reasonable prices. It is sufficient to say here that there is no loading tool in existence that will not reload good ammunition if it is used carefully and with a clear understanding of the results that must be accomplished.

Any person desiring to enter the ranks of the handloaders will do well to obtain and study the catalogues and handbooks of the loading manufacturers and to purchase the type of equipment which seems to suit his particular desires, as well as his pocketbook. Elaborate equipment is not necessary and this writer believes that the beginner should purchase the very minimum of equipment at the start, adding to it as his particular needs and experience dictate.

A little actual experience in reloading cartridges will be found more valuable than reading all the handbooks in creation and the directions which accompany loading tools are sufficient to begin on. Without some experience as a foundation, the comments in handbooks are likely to prove confusing to the beginner, especially those comments that go into the more intricate details of handloading. Look upon books about this subject as correspondence courses on the subject of handloading. One would hardly expect to progress very far in the subjects of mechanical drafting or electrical engineering without drawing instruments or electrical apparatus with which to work and for the same reason books should be used in connection with the loading tool. In short, the only real way to learn how to load ammunition is to load some ammunition.

The following firms manufacture loading tools suitable for the use of the individual handloader and in addition most of them manufacture or can supply powder measures, bullet moulds and other necessary handloading accessories.
Modern Bond Company, Wilmington, Delaware.
Belding and Mull, Philipsburg, Centre County, Penna.
Lyman Gun Sight Corporation, Middlefield, Connecticut.
Pacific Gun Sight Co., 355 Hayes St., San Francisco, Calif.
Yankee Specialty Company, 851 E. 6th St., Erie, Penna.

The selection of a loading tool is not always easy for the novice, lacking, as he must, any real knowledge of handloading and often the information he gives the manufacturer in his initial inquiry is inadequate for the latter to make better than a general suggestion as to the equipment which will best suit his purpose. Any manufacturer can and will suggest proper loading equipment if given complete information, and the following facts should be included in the inquiry:—

1. The make, model and caliber of the arm you intend to load ammunition for. By "caliber" is meant the manufacturer's designation of the cartridge the arm shoots. For example, "a Cal. .38 Colt revolver" or "a .250/3000 Savage rifle" would be insufficient. In the first instance, ".38-caliber" means nothing, as there are many different .38-caliber cartridges and the correct name of the particular cartridge as well as the model of the revolver should be given. In the latter example, the cartridge is specified plainly enough, but cartridge cases usually stretch more in the Model 99 Savage than in the Models 20 and 40 made by the same manufacturer and they therefore may require different treatment and different equipment in order to reload them satisfactorily.
2. You should also specify whether you wish to reload ammunition with cast bullets, or with factory metal jacketed bullets, or both, as in some cases this also has considerable bearing on the type of equipment necessary.
3. It will do no harm to mention the main purpose for which you intend to use your loaded ammunition; that is, whether for short or mid-range target shooting, small game or vermin hunting, long range military target shooting, or what.

If you will always give the manufacturer this information it will aid him materially in suggesting the particular items that you will need in order to best accomplish your purpose.

PART ONE

Cartridge Components

Chapter One

THE CARTRIDGE CASE.

The cartridge case is the primary component with which we have to deal in reloading ammunition and its condition after firing, as well as its care, are of importance to the safety and accuracy of our reloaded ammunition. Early attempts to make breech loading arms were largely unsuccessful up to the time the cartridge case was invented, for despite attempts to seal the breech with carefully fitted parts, gas would escape from there in close proximity to the shooter's face, a condition conducive neither to comfort, safety, good shooting or good ballistics. The brass cartridge case solved this difficulty because the thin walls of the case, pressed firmly against the chamber walls by the expanding gases, made a perfect "obturator" or gas seal and effectually prevented any escape of gas to the rear. THE CARTRIDGE CASE SHOULD ALWAYS BE THOUGHT OF AS A PART OF THE ARM IT IS FIRED IN and not merely as a convenient container for transporting charges and loading them into the gun.

For a better understanding of this function and the development of this important component, let us briefly look into its history. One of the first breech loaders that was considered as reasonably successful was the Sharps. This arm has a vertical sliding breech block which fits closely against the rear face of the barrel. It used a linen cartridge
1 containing the bullet and powder, but was fired by a percussion cap. The cartridge, when inserted in the chamber, projected enough so that the sharp edge of the breech block sheared off the rear of the linen envelope in closing, leaving the powder exposed to the flash of the cap. When the arm was fired there was more or less escapage of gas to the rear, causing erosion of the metal surfaces and consequently a continual increase in the escape of gas.

Another early breech loader was the German Dreyse or "needle gun" used by the German Army in the Franco-Prussian War. This was a single shot, bolt action rifle using a fabric cartridge which was peculiar in that the primer was placed at the base of the bullet and was fired by a long, sharp needle that penetrated the powder charge. There was a considerable escapage of gas through the bolt of this rifle. The French picked the idea up and improved upon it in their Chassepot rifle by incorporating a rubber gasket or washer in the bolt which expanded and formed a gas seal under the pressure of the powder gasses, however the sulphur in the powder quickly hardened the rubber and made it ineffective.

Other noteworthy advances were the Boxer cartridge used in the British Snider rifle and the French Lefaucheux or "pin fire" cartridge. The former employed a rimmed case of more or less conventional form, having a body of coiled

The Lefaucheux Cartridge.

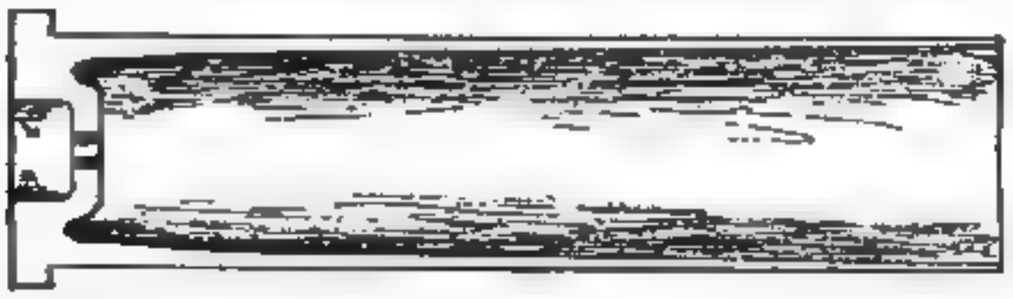
brass and a separate head of cast iron. The latter was designed like the sketch shown herein, having a self-contained firing pin that projected from the side of the base. Arms using this cartridge had a notch in the breech of the chamber to accommodate this pin, which was struck by the hammer and driven against the internal primer. The Le- 3
faucheux cartridge was not particularly convenient to handle, transport or load and was dangerous if dropped.

The first one piece, drawn brass cartridges cases of the type with which we are familiar were made of thin brass with the heads or rims bent or folded, much as our present rim-fire cartridges are made today. The brass was so thin that it was usually necessary to employ a reinforcing band of brass inside the case, near the head, to support the strain

The original folded head case.

at this point. These were the original and true "folded head" cases, but they could not be resized as the heads were too thin to stand driving out of a resizing die. This type of case has not been manufactured for many years and is not likely to be encountered now, except in obsolete cartridges of considerable age. Because these early cartridges were expensive, reloading was universal and most arms manufacturers supplied reloading tools for the users of their arms. Winchester, Remington and Smith & Wesson made their own, but Colt seems to have catalogued and supplied Ideal reloading tools to the users of their revolvers.

Naturally, the reloaders of the time were not satisfied with the thin, folded head type of cartridge case. The corrosion caused by the use of black powder quickly weakened the brass, the expansion of cases due to firing was severe and they could not be resized. There was, therefore, a universal demand for a stronger case that would overcome these objections, so the solid head type of case was developed. This type was drawn out in the form of a cup, the walls of which increased in thickness towards the bottom, this latter being the thickest part. This bottom, or base, was later mashed or cold forged to form the rim, 4
while the primer pocket was bent or forced into the metal of the head, just as it was in the older folded head case. The difference in the primer pockets of these two types of case was practically in the thickness of the metal, and in both types the formation of the primer pocket created a raised hump on the inside of the head of the case. Strangely enough, this cartridge case that was once hailed with joy by reloaders; this case that came in boxes boldly labeled "solid head," and with directions that extoled their virtues for reloading purposes, are today known as "folded head" cases. The term "folded head" is not a correct one to apply



The original solid head case—today known as the folded head.

to them, as a comparison of the cross sections of the different types of cases shown here will make it clear that their heads are not really folded at all. Nevertheless, the term is in common use and throughout this book the term "folded head" will be used in referring to this type of cartridge case, unless explained to the contrary.

But this new case had its limitations also. It was satisfactory with black powder loads, which rarely developed pressures of more than 30,000 lbs. per square inch. When smokeless powder came into use and chamber pressures were increased up to 45,000 and even 50,000 lbs. per square inch, thicker and stronger case heads were necessary. During this period of transition the Ideal Everlasting case was brought out.

The Ideal Everlasting case was a drawn brass case with thick side walls, much thicker than commercial cases of the time, and with solid heads, as we employ the term
5 today. That is, the rim and head of the case were one solid mass of metal, with the primer pocket forged or mashed into the brass, without indenting the interior of the case at all. Incidentally, these cases often had the primer pockets carefully reamed to size. The walls of Everlasting cases were too thick to permit crimping and they were only suitable for use in single shot rifles. They were expensive, but were practically "everlasting" when properly cleaned and cared for after firing. The illustration here shown is of

The Ideal Everlasting case. Modern solid head cases of today are made on this principle.

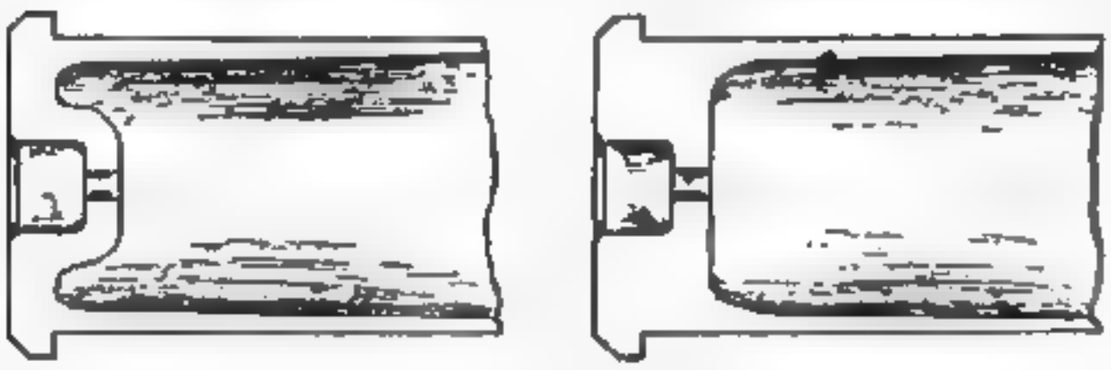
a .40/90 Ballard Everlasting case, it will serve to give an idea of the heavy structure of Everlasting cases, which were only made for straight or straight taper chambers. The thickness of these cases depended upon chamber and bullet diameters.

The use of solid head cases became general for all smokeless rifle cartridges developing high pressures. In recent years, with the development of the so-called high speed revolver cartridges, the use of solid head cases has been extended to some revolver calibers and the folded head type is fast disappearing.

In this rather sketchy description of the development of the cartridge case, there has been no purpose other than to show that this component has been improved and strengthened from time to time with the object of holding in the powder gases, *which is the primary function of a cartridge case*. The chamber and bolt or breech block of an arm are

insufficient to do this and these parts only act as supports for the case, which is in reality a part of the arm it is fired in and I repeat that it is important that the handloader always view the cartridge case in this light.

How Cartridge Cases Are Made. Cases are still 6
made of brass as this material can be easily obtained, it has the necessary strength if properly worked and it can be fabricated more cheaply than some other metals. Steel can and has been manufactured into cartridge cases but while steel is a much cheaper material than brass, it is far more expensive to fabricate and the high manufacturing cost much more than offsets any saving in the cost of the raw material. Incidentally, the use of steel cartridge cases would



Modern styles in case manufacture.

greatly increase the strength and safety of our present rifles, but is unlikely that this generation will see any steel cases used for commercial ammunition, unless some cheaper method of manufacture than we have at present is devised.

A detailed description of cartridge case manufacture would be of little practical use to the reloader but some understanding of the process and of the physical nature of the finished case is necessary in order to understand the changes that take place when the case is subjected to the strain of firing.

The general process consists in blanking out discs from strip brass and forming the discs into cups. These cups are forced or drawn through successive dies which elongate them, at the same time reducing their thickness and diameter. The heads and primer pockets are formed by cold forging the bases of the cups and the rims or extractor grooves are turned. The cases are given the proper taper or bottle-neck form by forcing one or more dies of the 7
proper shape over them, after which they are trimmed to the correct length.

The severe stresses and strains that cartridge cases are subjected to when fired, makes it necessary to use only brass of the highest quality in their manufacture for, it must be remembered, the cartridge case is part of the arm it is fired in and the safety of the arm and the shooter depend largely upon the strength of the case. The usual alloy used is about 70% of copper to 30% of spelter (zinc) and every care is taken to exclude impurities and other metals. In foundry parlance, "cartridge brass," means just about the finest brass that it is possible to procure.

Brass, when etched and viewed under a microscope, appears as a crystalline structure. The size and form of the crystals depends upon two things; cold work and annealing. Working, that is, drawing, bending or compressing brass while it is cold, hardens it by stretching or compressing the crystals, while annealing softens it, causing the crystals to re-form. The greater the heat and the longer its duration, the larger the crystals become.

In manufacturing cases, it is necessary to anneal the cups between each drawing operation and also before they are tapered or finish-formed. These anneals are carefully worked out with relation to the amount of cold work to be performed after them, so that the finished case will have the proper degree of hardness. The case must not be too hard or it will rupture when fired. On the other hand, if it is too soft it may give way when fired, ruining the rifle and possibly the shooter as well. All parts of the case are not of the same degree of hardness. In general, the head is of a tough, coarse structure, with the side walls gradually increasing in hardness towards the mouth of the case. The physical characteristics of different calibers are not the same, as each one presents its own metallurgical problems. However, what we are interested in knowing here is, that a cartridge case has a crystalline formation, that it is carefully 8
made to give it the proper strength and that both of these factors *can* be changed when the cartridge case is fired, although they normally are not.

The Cartridge Case and Its Chamber.

As the cartridge case is a part of the arm it is fired in, it is necessary to understand and to give some consideration to the arm, in order to understand the changes that take place in the case when a cartridge is fired. This change may be, and normally is, negligible, which has given rise to the general statement that cartridge cases are just as good and serviceable after firing as they were before. This statement is substantially correct, but not literally so, because some change *does* take place during the firing. It is perfectly obvious that if no change took place the first time the case were fired there would be no change the second time and so on *ad infinitum*. The kind and amount of change depends principally upon four things; the relation of the size and shape of the case to the chamber it is fired in, the pressure developed within it, the thickness and temper or hardness of the brass itself, and the products of combustion that are left in the case after firing. Any of these things or any combination of them can, under some circumstances, render a cartridge unsafe for reloading . . . but they usually don't.

Relation of Cartridge to Chamber. The chamber of an arm is the recess provided in the rear of the barrel or cylinder to receive the cartridge. As cartridge cases are made of springy brass, it is impossible to make them all exactly alike and the cases of each caliber will, if measured very carefully at all points, be found to differ slightly. This variation in dimensions will not only be found in different makes of cartridges of the same caliber but are present in cartridges of the same make and even among those from one lot produced on the same machines. The uniformity in dimensions of all calibers of our American ammunition is truly remarkable and the little differences referred to here are what are known as manufacturing tolerances, or the 9
slight differences that can be permitted without affecting the serviceability of the finished product. The smallest cartridge of any given caliber is known as a minimum cartridge, while the largest permissible cartridge is called a maximum cartridge. The differences in any of the dimen-

sions between the two will ordinarily not exceed a few thousandths of an inch.

Chambers and Chambering. The chamber of a rifle, or the recess in the rear end of the barrel into which the cartridge enters, has a great deal to do with the accuracy of the arm. The reaming of chambers is one of the exacting operations of arms manufacture, calling for the utmost skill and care. While it is possible, with modern machine tools, to chamber arms accurately and at the same time quite rapidly, nevertheless the work must be done by men who have had long experience with it. Perhaps it can best be said that the work of chambering *should* be done by men of long experience, for we sometimes encounter chambers that would reflect discredit on the village blacksmith. Naturally, the price of the rifle has something to do with this and a cheap arm that is hacked out to sell at a low price can not be expected to have the careful and painstaking workmanship that is put into the production of a more expensive one.

Chambers are made after the barrels are reamed and rifled, and they are formed by a series of reaming operations. The breech of the barrel is drilled out to remove excess metal, after which one or more roughing reamers are run into it to the proper depth, to bring the chamber approximately to shape. These first operations leave the chamber too small at all points and do not go in to the full depth of the finished chamber. The character of the surface of the chamber is of no importance at this stage.

The chamber is brought to its finished size and shape by the use of additional reamers, each one of which removes only a small amount of metal. The difference between the finishing reamer and the one that precedes it is often little more than a thousandth of an inch. This final reaming 10
must be done with great care and with a carefully stoned reamer, in order to give that very smooth surface to the chamber which is so necessary to the easy extraction of fired

[redacted]

So called straight chambers, like those for revolver cartridges, are the easiest to make, while bottle-neck chambers for rimless cartridges offer the most difficulty; especially where the type of arm requires that the barrel be finished chambered before it is assembled to the receiver, as in lever action rifles. Barrels for bolt action rifles, as a rule, have the chambers left a few thousandths of an inch too short. After the barrel is assembled to the receiver, the chamber is reamed by hand to bring it to the proper depth with relation to the bolt, so that the head space will be correct. This head space reaming is confined almost entirely to chambers taking rimless cartridges and where the design of the rifle permits it, it can be done more precisely *after* the barrel is fitted to the receiver than before.

Chambering reamers, like all others, must be sharpened from time to time and this sharpening or stoning gradually reduces their size and, to a certain extent their shape until they can no longer be used. A finish reamer, which gives the chamber its final size and form, when worn out, is usually reduced in size and used on the next preceding operation, but between the time it is first put in use and the time it is worn out there is a difference in the sizes of the chambers cut by it. Slight differences will exist without any change in the reamer itself, so that the production of two or more chambers that are *exactly* alike is a matter of chance. In addition, no two reamers are *exactly* alike, except by chance and different manufacturers may have different ideas as to the chamber form and taper they wish to use, which is influenced by the nature of the arm being made. Ordinarily, the greater the taper of the chamber, the easier the extraction of fired cartridge cases will be and a little more taper is necessary in the chamber of an arm
11 having a limited amount of power or leverage for extracting, than in a bolt action rifle having a powerful camming action for the extraction of fired cases.

It is not the intention to go into the details and problems of chambering here, but the reloader should understand that chambers of the same caliber differ considerably between makes and models of arms and also, to a lesser extent, in arms of the same make and model. It should also be understood that the mere fact that a chamber appears to be large and permits a visible expansion of the cases fired in it, does not mean that the arm is poorly chambered. Such a chamber may be necessary to the proper functioning of that particular arm and is to be distinguished from a poor chamber.

Head Space.

While the chamber proper supports the walls of the cartridge case against the severe stresses incident to firing the cartridge, the total over-all length of the chamber, in relation to its cartridge, is governed by the bolt or breech block that closes it and supports the head of the cartridge case. In other words, the location of the face of the bolt or breech block, governs the head space of the arm.

The head space of an arm is the distance from the surface of the chamber or barrel, that positions or prevents further forward movement of the cartridge into the chamber, to the face of the bolt or breech block when the latter is fully back against the shoulder that supports it. Rimmed cases are positioned by the rim which bears against the rear face of the barrel or, in the case of revolvers, against the rear surface of the cylinder.

Rimless cases present a special problem for, as their name indicates, they have no rims to act as a stop against their forward movement into the chamber. The shoulder of the case serves this purpose, therefore the head space of a rifle for a rimless cartridge is the distance from the beginning of the shoulder of the chamber to the face of the bolt. The measurement of head space is taken from the beginning
12 of the shoulder, because the angle of the chamber shoulder and the angle of the shoulder of the cartridge case are not the same, the former being the less abrupt of the two.

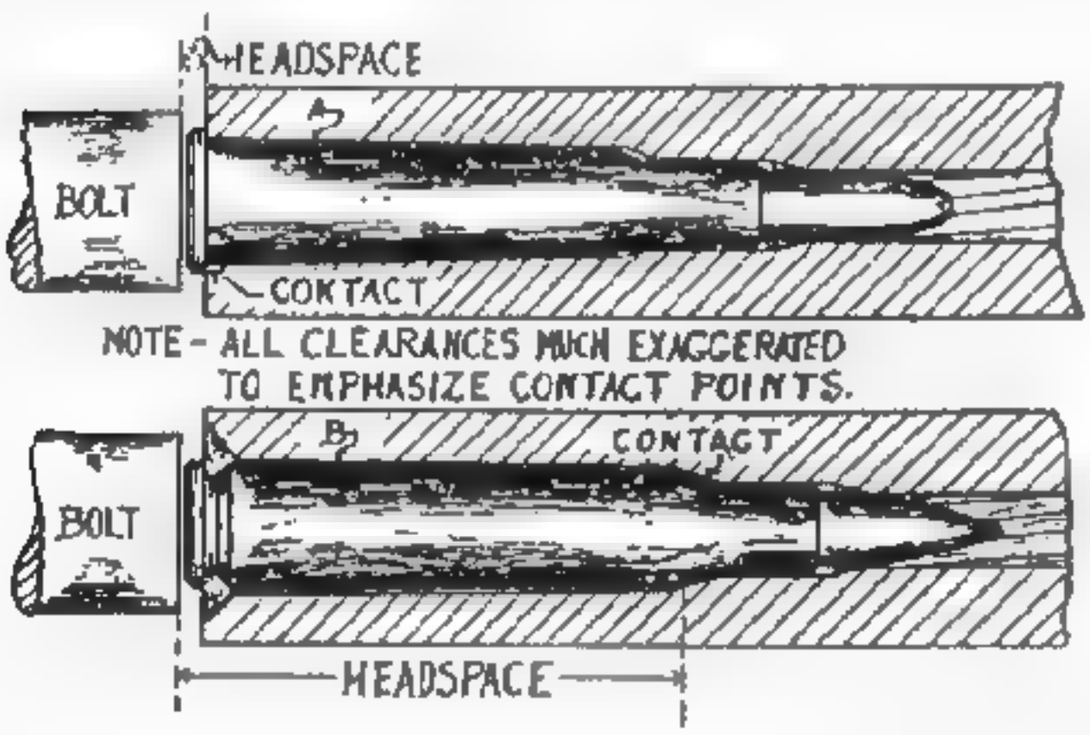
There is usually a small amount of play between the face of the bolt and the rear of a rimmed cartridge, when the latter is in the chamber. The clearance must be sufficient to take cases of maximum rim dimension, plus a small allowance for the occasional thick rimmed case that will always get by the inspectors once in a while. Consequently, with cases of a minimum rim thickness there will be several thousandths of an inch clearance between the head of the case and the bolt. The rim of the case, being of solid metal, can not be compressed and if the fitting of the bolt were too close, it would frequently be impossible to close it on

the cartridge.

The situation is different with rimless cases. The head space may be greater than the shoulder to head length of the cartridge but it may also be, and frequently is, less. The bolt will close on a rimless case that is longer than its chamber, because there is an opportunity for the shoulder to give slightly under the pressure of the bolt, or the case walls may spring out slightly, or both. Furthermore, as a new cartridge is always smaller than its chamber, its forward movement into the chamber is not stopped precisely at the beginning of the chamber shoulder. For these reasons, the head-to-shoulder length of the cartridge may be greater than the corresponding length of the chamber and still have the arm function satisfactorily.

When, due to the set-back or wear of the locking surfaces of a bolt or breech block, the head space exceeds the maximum limit set by the manufacturer of the arm, the arm is said to have excess head space. Many people are under the impression that "excess head space" indicates a dangerous condition, just because a few arms having this condition *to an abnormal degree* have been known to blow up. This idea is fallacious, for it is obvious that no reputable manufacturer is going to put out arms that are on the ragged edge of being dangerous. The maximum limits of head 13
space for all rifles are established so as to leave a very liberal margin for any increase that is likely to occur through ordinary usage.

Influence of Head Space on the Case. The diagram on this page shows the points from which head space measurements are taken for both rimmed and rimless cartridges. It will be observed that most of the solid head



of the rimmed case is well within the chamber, while only a small part of the solid head of the rimless case enters the chamber. It will also be noted that the necks of the cases (new cases) do not reach the forward end of the chambers. This clearance is provided to insure proper functioning of the arm, even if an occasional case of extra length is loaded into the chamber. It also provides for smooth operation in spite of any minor fouling of the chamber.

When a cartridge is fired and the burning powder begins to build up pressure in the chamber, the thin walls of the case expand, gripping the walls of the chamber. If there be any excess head space, the blow of the firing pin will usually drive the cartridge forward, leaving a space between the face of the bolt and the cartridge head. With the walls of 14
the case gripping the chamber walls, the head of the case will be driven back against the bolt. This will stretch the brass to a greater or lesser extent, depending upon the distance that the head moves. The point of strain is usually at about the location of A and B on the sketch, although it may occur further forward. This stretching will thin down the brass in the walls of the case and weaken it and if the excess head space or the movement of the case head to the rear be great enough, a complete head separation will occur. When there is a partial or complete separation of the head of a case at high pressure, there is a possibility of injury to the arm, the shooter, or both, but often there is enough of the side wall left to act as an obturator and stop most of the gas. This is especially true of the rimmed type of case, which has practically all of the solid head within the chamber. Such gas as may escape to the rear is deflected by the rim of the case, so the separation of the head of a rimmed case seldom results in injury of any kind to the arm or to the shooter.

With rimless cases, the situation is not so good. The point where the head usually separates is so close to the end of the chamber that the likelihood of gas escaping to the rear is much greater than with the rimmed case. In addition, the rimless case has no rim to deflect this gas, which, in bolt action rifles, will come back through the bolt, causing eye burns or perhaps more serious injury, accompanied by the wrecking of the rifle. This can also happen with some lever action rifles, except that one is relatively safe from eye burns with rifles having solid or completely enclosed actions. However, such rifles are harder to head space accurately and when a head separation is accompanied by the escapage of a considerable amount of gas *at high pressure*, the shooter is in for trouble regardless of the kind of rifle he is using, for *no arm is safer than the cartridge cases used in it*.

Assuming that the head space is not great enough to cause a head separation, the cartridge case will be stretched and expanded to fit the chamber perfectly. If it is not resized 15
or if it is only resized at the neck, the head will be in perfect contact with the bolt the next time it is fired and there will be little or no further stretching of the case. Naturally, excess head space will cause the case to lengthen, will reduce the thickness of the side walls near the head and there is no way of returning the strained part of the case to its original condition. If the case is resized full length, it will merely set the shoulder back the same distance that the case stretched and will give the case the same clearance between the head and the bolt that it had originally. When fired again, the head will set back again and the side wall will be further weakened or may even tear apart. Mercuric primers will aggravate this condition, as the mercury will penetrate the strained brass rapidly and render it brittle and useless, even at low pressures.

If you have a rifle in which head separations occur with factory loaded ammunition, it is a pretty good indication that the arm has an excessive and dangerous amount of head space and you should communicate at once with the manufacturer regarding its repair or adjustment.

Cartridge cases loaded with high pressure loads will lengthen even though the bolt or breech block be in firm contact with the head of the case. The brass is forced

forward and while this does not ordinarily result in any weakening of the case, there are exceptions to this general rule. It may be a matter of chance or it may be due to soft spots in the case but occasionally a case wall will be weakened from this cause. The strain, if any, may occur anywhere from the shoulder back to the head of the case. A few years ago, the writer conducted a series of experiments for the Cuban Army, in order to determine the approximate rate of elongation of the .30-06 cartridge case. Some .30-06 ammunition was fired in a rifle having the minimum head space of 1.940 inches, then ammunition from the same lot was also fired in another rifle having the maximum head space of 1.946 inches. The cartridge cases from each rifle were kept separate and were reloaded with the Model 1906 bullet and a powder charge developing 2,700 f.s. muzzle 16
velocity, at a pressure of 49,000 lbs. per square inch. After each firing, the cases (each one stamped with an identifying mark) were measured for increases in length and were resized so the body length was 1.9487 inch.

The cases fired in the rifle having minimum head space showed an average elongation of .027 inch after four reloadings plus the original firing, while those fired in the rifle with maximum head space showed an average elongation of .035 inch with the same amount of firing. The only case which showed any localized weakening was thin as paper *at the shoulder*, but this case might have been thin at this point originally. Practically all of the cases were increased in length so their mouths were jammed into the forward end of the chamber after the fourth reloading but, with the one exception mentioned, all could have been made serviceable again by trimming back to their original length.

Cases will elongate when reloaded with full charges. If this elongation prevents the free entrance of the case into the chamber, the mouth of the case can, without harm, be filed or reamed enough to shorten it slightly. Reamed is preferable.

Some rifles have bolts or fairly long breech blocks that lock at the rear end, instead of at the front immediately back of the cartridge. Such arms, while perfectly safe, permit cases to stretch noticeably when fired with high pressure loads. The bolts, being supported at the rear, have a tendency to spring or buckle slightly under the thrust of the cartridge head and it is not infrequent that a high power cartridge case from such an arm will fail to enter its own chamber again, at least it will not go in far enough to permit the action to be closed. This stretching produces a condition similar to that caused by the presence of excess head space and where this condition is encountered, it is advisable not to reload the fired cases with full loads. The cases must be entirely resized to be used and with full loads the stretching will be repeated, which may lead to head separations.

Expansion of Cartridge Cases. It has been pointed 17
out that cartridge cases of the same caliber will vary slightly in their dimensions and that chambers of the same caliber will also vary. These variations are remarkably small but they do exist. It is obvious that the smallest chamber of any given caliber must be large enough to take the largest cartridge made for it and, conversely, in manufacturing the ammunition, the maximum cartridge must be kept *within* the size of a minimum chamber of that caliber. When a maximum cartridge is put into a minimum chamber there will be a small clearance between the two, that is, the unfired cartridge will enter and extract from the chamber freely. However, when a minimum cartridge is put into the same chamber the clearance is greater and, if we make the same comparison with a maximum chamber it is easily seen that the clearance between cartridge and chamber is still further increased.

When a cartridge is fired, the internal gas pressure forces the walls of the case firmly against the chamber walls and after the bullet has left the bore and the pressure drops to zero, the walls of the case do not go back to their original position. The case will have taken on a permanent set and expanded to perfectly fit the particular chamber it was fired in. The springy nature of cartridge cases cause them to spring back slightly after the pressure drops so that they may be extracted easily and in most instances they will reenter the same chamber without difficulty. As already explained, if there is spring or set back in the bolt or breech block, the case may elongate in a way that will prevent its re-entering the same chamber again without resizing, but elongation and lateral expansion are two different things and they affect the cartridge case differently.

In any normal commercial or military chamber the expansion that takes place in the cartridge case is unimportant, except that it is *improved* in as much as it is now a "tailor made" case, fitting its particular chamber more perfectly than it could be made to fit by any other means. If it has not
18 been weakened by stretching, the case may be reloaded with charges approximating the original factory charge, or at least the original factory pressure. On the other hand, if either the stretching or the expansion is excessive at any point, the case should be used only for reduced loads, or discarded if the condition is bad enough.

Split Necks. Excessive expansion at the neck may cause a split or opening to occur at that point. Occasionally, and particularly in old ammunition, cartridges may be found with the necks split, due to season cracking. These split necks may be visible or they may split under the stress of firing. There is no danger connected with the shooting of cartridges having split necks, but their continued use is likely to cause some erosion of the chamber neck which may lead to extraction difficulties. If such ammunition is used, a loaded cartridge should *never* be extracted from the chamber without making sure that the bullet does not remain in the barrel. Should the bullet remain in the barrel, it might be possible to seat another cartridge having a loose bullet behind the first one. Forcing the second bullet back onto the powder charge would increase the loading density and cause a rise in pressure, to say nothing of the great increase in pressure that would result from the weight and resistance offered by two bullets. Under such circumstances, if the arm were discharged, the barrel would be ruined and the pressure might be sufficient to cause the cartridge case to give way at the head, wrecking rifle. The usual effect of firing two bullets at the same time is to ring or bulge the barrel. The rear bullet starts out at a greater velocity than the forward one. The resistance offered by the forward bullet causes the point of the last and the base of the first bullet to expand violently at some point

along the barrel and the radial pressure is sufficient to expand the steel outward. This makes a visible, dark ring in the barrel and may cause a bulge on the outside. Occasionally a barrel will split lengthwise from this cause. Lead bullets can make just as nice rings in a barrel as jacketed bullets, and high pressures or velocities are not necessary to 19
do it either. The lowly .22 rim fire cartridge can ring a barrel beautifully, if two bullets are fired at one time. Incidentally, ringing a barrel in this way will not affect its accuracy, at least, this writer has ringed a few barrels and has shot quite a few others that were ringed and has never observed any loss in accuracy from this cause. But, as far as cartridges with split necks are concerned, by far the best policy is to not shoot such cartridges. The bullets and the powder from them can be salvaged and loaded into good cases with very little effort and expense.

Season Cracking. This condition arises from internal stresses in the brass itself. If brass is too hard it may crack spontaneously in time, especially in hot climates or if subjected to corrosive gasses, also long continued strain of any kind may cause it. Season cracking is not a condition that occurs only in cartridge cases but is more or less common to all drawn brass articles. The condition is most frequently encountered in the form of split necks in .30-06 ammunition manufactured during the World War. This ammunition was made hurriedly and with the belief that it would be used within a relatively short period of time. The necks of most of the cases were quite hard and under the strain imposed on them by holding the bullets under tension, the necks were apt to crack after a time. Since the war, the necks of practically all cases of rifle ammunition have been subjected to an additional annealing process that relieves the internal stresses, without rendering the brass too soft to hold the bullets properly. This makes the case necks better able to withstand the repeated reducing and expanding that is often necessary to properly reload them. Season cracking in small arms ammunition is practically a thing of the past and is only mentioned here as being of casual interest.

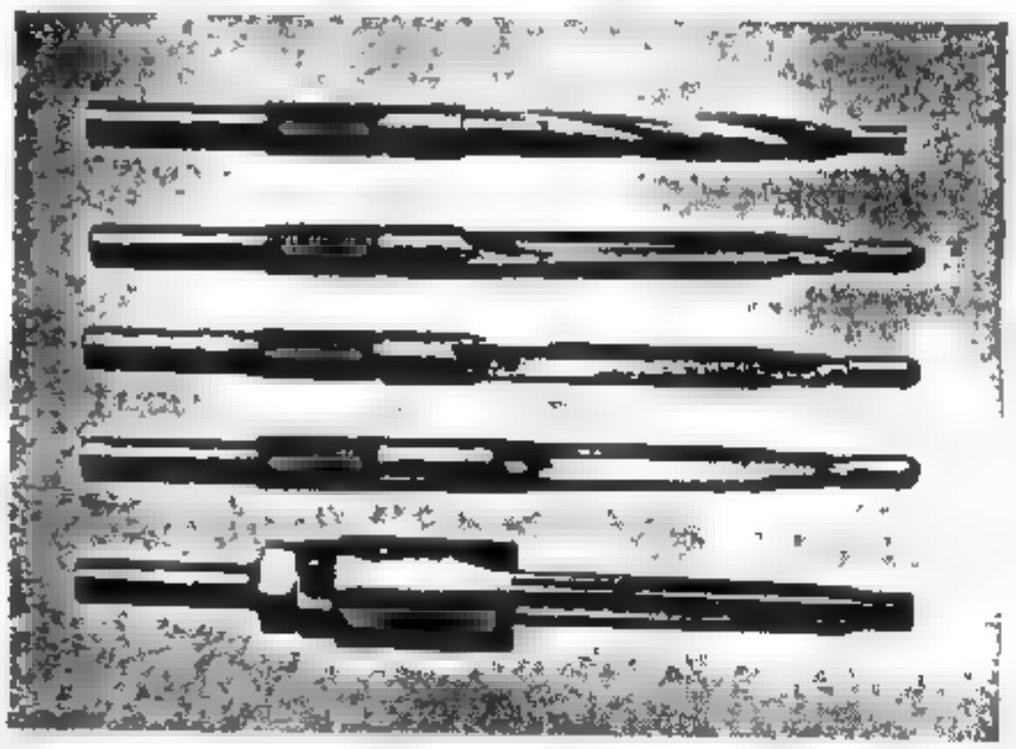
Body of the Case. Practically everything that has been said above with regard to the expansion of the necks of cartridge cases applies to the expansion of the body of the case as well. If the case is of the straight or cylindrical type, the body and neck are continuous and in this type 20
the term "neck" is applied to that part of the case that is normally occupied by the bullet. In a straight taper case, such as the .32-40, .38-55, .45-90, etc., there is no definite line of demarkation between the cylindrical neck that holds the bullet and the tapered body. The distinction is very definite in the bottle-neck case, but in referring to the "body" we mean that part of the case between the neck or shoulder and the head, or the part of the case that contains the powder charge.

The degree of expansion of the body usually determines whether the case must be completely resized before reloading or not. The resistance offered by an excessively expanded neck is not of itself sufficient to offer difficulty in extracting the case from the chamber. All cases are not of the same degree of hardness or "springiness." The product of any one manufacturer will be found to run quite uniform, but there is often a considerable difference in the cases of different makes. Soft cases will not spring back from the chamber walls quite as much as harder cases and if soft cases are reloaded with full charges they are apt, after one or more reloadings, to be not only difficult to extract but also difficult to re-enter in the chamber in which they were fired. The remedy is to resize them in a suitable die and in doing this it is a good rule to only resize them enough to permit their entering the chamber easily. The complete resizing of cases should be avoided wherever possible, for reasons that will be explained later.

Splits or ruptures may occur in the bodies of cartridge cases; splits from excessive expansion, hard brass, defects in the brass or a combination of these things. Ruptures in the bodies of cases (except near the heads) are usually due to manufacturing defects and are of rare occurrence. Neither of these defects will cause injury to the arm or the shooter, provided that the break does not occur close to the head. The body of the case is, "just the part in between." The relation of the case neck to the neck of the chamber is of
21 importance to accuracy as will be explained later, while the head, and the body for a short distance in front of it, takes much of the stress of firing and is important from a safety standpoint. The body just connects these two parts together and no harm is likely to occur if it splits.

Micro-photographs of brass—showing difference in crystalline structure.

Hard Worked Partially annealed Fully annealed



A Set of Machine Gun Chambering Reamers.

PLATE I.

Cartridge Case Head. In referring to this part of the case, it is intended to include that part of the body just in front of it where the side walls are thickest. Being the safety end of the cartridge, this part is worthy of the special attention of the reloader. In addition to sealing in the gasses, it contains the primer pocket and flash hole, or

The Cartridge Case.

vent, and it is the part by which the case is extracted from the chamber. If a rimmed case, the rim serves to position the case in the chamber and affords a solid support to the blow of the firing pin, a more solid and satisfactory support, by the way, than the springy shoulder of the rimless case. Heads may be of the solid or the so called folded head types, the former predominate in present day ammunition, the latter being principally confined to revolver cartridge cases. Even in the latter there is a gradual swing toward the solid type of head, made necessary by the high speed loads with which some revolver cartridges are now being loaded. These loads develop pressures above the 15,000 lb. limit that is the accepted maximum for use in folded head cases and it is quite probable that in a few years time the folded head case will become a thing of the past.

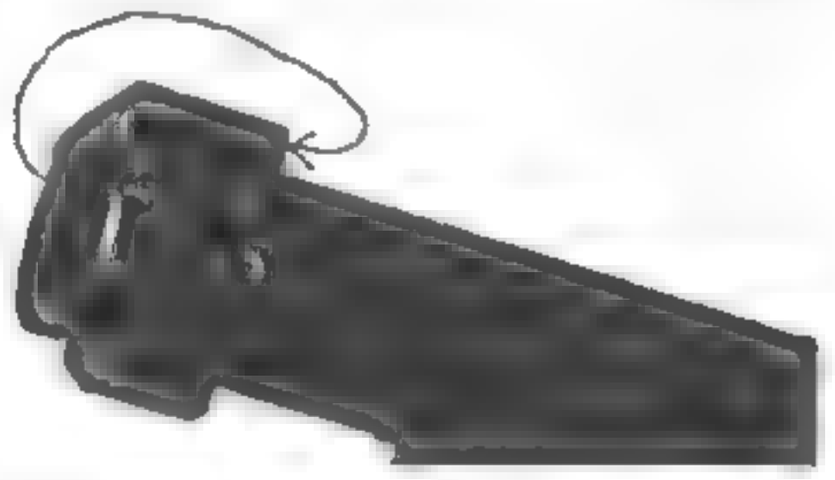
The thickness of solid heads will run uniform in any one lot of ammunition and generally in one make of a given caliber, but a considerable difference in the thickness of the heads, as well as in the thickness and taper of the side walls, may be found in different makes of the same caliber.

22 As the *outside* dimensions of these cartridges must be kept the same, within close manufacturing tolerances, any increase in the thickness of the head or the side walls will result in a decrease in the volume of the cases. If two cases having different volumes are loaded with the same powder charges and bullets, the case with the least capacity will develop the higher pressure. With reduced or normal full charge loads, such a condition is not likely to be dangerous, but it might easily be a serious factor with maximum loads.

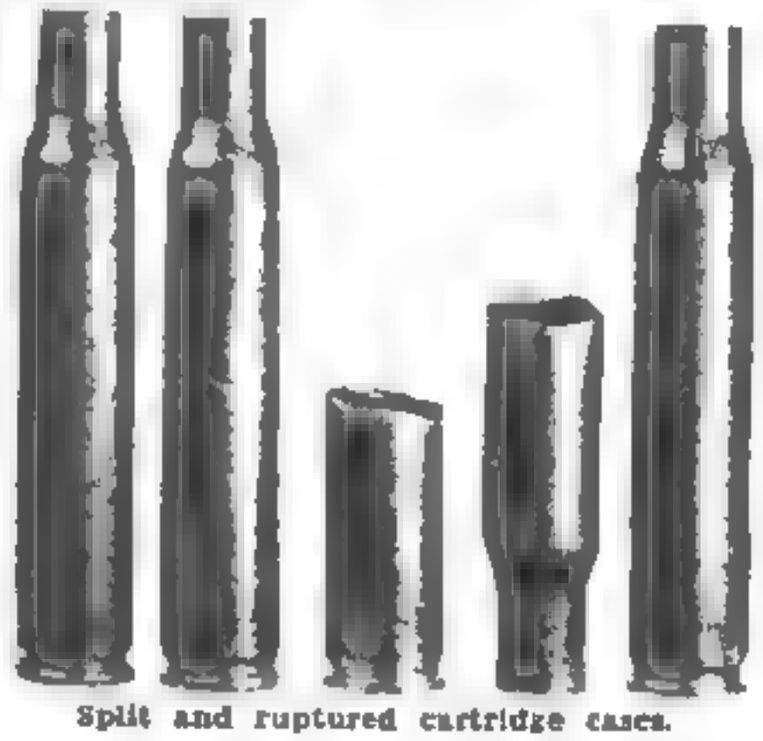
It has already been explained that chambers have a greater taper than the cartridges which go into them, in order to permit easy extraction, and that the taper varies in different types of arms of the same caliber. This sometimes results in a rather loose fit between cartridge and chamber at the head and permits a severe expansion of the case at the junction of its side walls and the head. This causes the metal in the solid head to tear apart for a short distance. If the case is resized completely, the torn metal will be pressed together, but the torn surfaces will not unite into a homogeneous structure. Upon firing the case again with a full or approximately a full charge, the same amount of expansion will take place once more and the violence of the expansion will cause the brass to tear further. The illustration on Plate III shows such a condition. This is a photograph of a factory cartridge after the first firing and the dotted lines show the approximate form of, and the condition as it would apply to a rimless case. This condition is no joke and is worthy of the consideration of every careful reloader. The only practicable method of determining whether or not this condition exists is to examine the fired cases for expansion near the head and if the expansion appeared to be excessive, to section a few cases and look for torn metal in their solid heads. The correct method for doing this is described on page 31.

If heads tear in this way and the cases are *not* completely resized, when they are reloaded and fired the case will be in close contact with the chamber walls because of the expansion that already has taken place, consequently there will be very little or no further tearing of the brass in the solid head. Nevertheless, cartridge cases that expand excessively near the heads should not be reloaded with anything except reduced loads.

23 Primer pockets and vents, being closely related to the performance of primers, will be discussed under the subject of "primers" in Chapter 2.



The distance from the face to the rear of the locking lugs is the most important dimension on a rifle bolt and is held very close.



Split and ruptured cartridge cases.

PLATE II.

The Care of Fired Cartridge Cases.

If cartridge cases that have been fired with smokeless powder are to be kept for some time before they are reloaded, they should be stored in a dry place but otherwise they require no particular care. If the necks of the cases are smoked up a little, this fouling may be wiped off with a cloth, provided the wiping is done within a short time after they are fired. While this fouling is easily removed when fresh, if allowed to remain for some time it will result in oxidization of the brass. This oxidization will do no harm except that if the brass be left under strain, it will accelerate any tendency to season crack. If cases are kept in a damp place they will have a tendency to corrode, the corrosion being noticeable as discolored patches having a hard granular feel to the fingernail in the early stages. As the corrosion progresses verdegris will form. Cases showing

any considerable corrosion should be discarded.

Hand books on reloading ammunition have usually carried a description of one or more methods of washing cartridge cases so as to make them practically as bright and clean as when new. In the opinion of this writer, the washing of cartridge cases that have been fired with smokeless powder is not only unnecessary but inadvisable, except under special circumstances. Cases fired with black powder *must* be washed to prevent them from corroding. Black powder leaves a heavy deposit of fouling in the case and this fouling will gather dampness rapidly. The sulphur in the fouling, when in the presence of moisture, attacks the brass rapidly, causing verdegris to form and weakening the case 24
materially.

If cartridge cases that have been fired with smokeless powder are to be reloaded for military use, or for issue to men who know but little of ammunition and are apt to judge it by appearance as well as its performance, or if the ammunition is to be stored for a long period of time, there is some justification for cleaning the cases so they will have a new appearance. Otherwise, washing cases is an unnecessary labor amounting to a waste of time. The reason for suggesting that cases be not washed is because most of the factory ammunition being turned out today is loaded with primers containing fulminate of mercury. The mercury left in the case by the fired primer attacks the brass more or less, depending upon circumstances that will be touched upon later, and renders the brass brittle and unable to withstand the strain of further firing. The use of any solution, whether acid or alkaline, on cases that have been fired with mercuric primers will hasten the action of the mercury and cause it to penetrate the brass deeper than it would have otherwise. Even plain water, in combination with the products of combustion in the cases, will accelerate this action. Hence the suggestion that cases fired with smokeless powder should be stored in a dry place and that they should not be washed or chemically cleaned, except under unusual circumstances.

Washing Cartridge Cases.

It may seem a bit out of place to suggest methods of washing or cleaning fired cartridge cases immediately after advising against the practice, but the reader should bear in mind that the one serious objection to the washing of cases lies in the possibility of their having been fired with mercuric primers. If a case has *never* been fired with a mercuric primer, there is no danger attached to washing or cleaning it with any kind of a solution. Such cleaning may be entirely unnecessary, but it will not harm the cases if they have *never* been fired with a mercuric primer. Please excuse the emphasis on that word "never" but the writer has seen 25
too many instances where reloaders only give consideration to the type of primer which they themselves use in reloading their ammunition, without taking into account the primer with which the ammunition was originally loaded at the factory. Most of the factory ammunition being produced today is loaded with mercuric primers and one manufacturer in particular who has been loading his ammunition with non-mercuric primers is slowly swinging back to the use of mercuric primers. Their reasons for using fulminate of mercury will be explained under the subject of "Primers."

The best time to clean cartridge cases is as soon as possible after they have been fired, as the fouling is then soft and has not had time to corrode the brass even superficially. If cleaned promptly, the cases will come out bright with less effort and with a shorter immersion in the cleaning fluid.

Cases fired with black powder should be decapped and dropped into a jar or can of water. The water will soften the fouling and facilitate its removal. If the cases are of a shape that will permit their inside to be easily reached with a swab on the end of a stick, they may be wiped out after they have soaked for a while. The primer pockets can be cleaned with a bit of cloth over the end of a wooden match stick. The best and easiest way to clean out black powder fouling from a lot of cases at one time is to boil them in soapy water, to which a small amount of baking or washing soda has been added. For a soap solution, any kind of soap or soap flakes may be used, including "Gold Dust" or "Oakite." Oakite is not really a soap but is a good cleaner. It is hard on the hands and should be used sparingly, as directed on the box. Treating the cases in this way will remove the heavy deposit of fouling from them, but may leave them dark and discolored, this will do no harm. Methods for brightening them will be given a little further on.

The fouling left by smokeless powder, while much less
26 in volume than black powder fouling, is much more tenacious and more difficult to remove. To do a good and thorough job, the method that has been published for years in the Ideal Handbook is probably the best and it is repeated here briefly for the convenience of the reader.

Two one quart jars are required for the chemical solutions and two jars or other containers for clear water, preferably running water. In jar No. 1, dissolve 2 ounces of potassium bichromate and add 2 ounces of sulphuric acid, pouring the acid in slowly while stirring the solution. In the other jar, dissolve one quarter pound of sodium cyanide. Potassium cyanide may also be used but is more expensive. Both sodium and potassium cyanides are deadly poison and should be kept out of and away from containers in which food stuffs are to be prepared or preserved. The solutions in both of the jars are poisonous for that matter, furthermore if mixed they will give off poisonous fumes, so it is best to work with them where there is a good circulation of air.

The proper arrangement of the jars for working is as follows; jar No. 1—clear water—jar No. 2—then another container of clear water.

To clean the cases, bend a piece of brass or copper wire a foot or more in length into the form of a narrow U. Then bend up the ends of the wire to form two hooks, on which the cases may be hung. Hang two cases on the hooks and dip them in solution No. 1 for a few seconds. Then remove them, rinse them thoroughly in clear water after which they should be immersed in the cyanide solution until they are clean and bright. This should require only a few seconds also but if the cases do not brighten up quickly, they should be rinsed thoroughly in the fourth container of clear water and the entire process repeated. The process of rinsing is important and if running water is not available, the water

in the two rinsing jars should be changed frequently to avoid carrying any of the chemical solutions from one jar to the other.

Another way to brighten cases and to remove corrosion, 27
and one that is not only good but is convenient and as old as the hills, is to immerse the cases in vinegar. This is especially good for brightening cases that have had black powder fouling removed from them, as described previously. Vinegar will not remove smokeless powder fouling as well as the acid and cyanide solutions, but it will remove a lot of it and if the cases are cylindrical, or of a shape that will permit of their being wiped out with a mop or a bristle brush, a very good job of cleaning out smokeless powder fouling can be done as the vinegar will soften and loosen the fouling in a few minutes, without injuring the cases in any way. Vinegar has the advantage of being easily obtainable anywhere, it is not poisonous, and its storage and disposition offers no problem, even where space is limited or there are children around. The particular kind of vinegar is not important; it may be old fashioned cider vinegar, synthetic vinegar, even the juice drained off from pickle bottles will work.

Possibly this pickle juice idea will stand some elaboration. The whole answer to this cleaning with vinegar is *acetic acid*. Cider vinegar and, presumably, the synthetic vinegars also, contain about 6% of acetic acid. It is this acetic acid which softens the powder fouling so that it may be wiped out easily with a rag. As to whether "pickle juice" will do the trick or not depends upon the amount of acetic acid (if any) that is present in it.

Acetic acid comes in different strengths, a solution of around 28-36% being used extensively in photographic work. The full strength acid is 99% pure and is strong enough to attack the brass of a cartridge case actively, a piece of a case put into a test tube with the full strength acid will cause the solution to turn blue in a very few minutes. A 10% solution is amply strong for cleaning cases, but bear in mind two things: That the solution only softens the fouling but does not remove it and, that in common with any other solution, acetic acid will promote the penetration of mercury into cases that have been fired 28
with mercuric primers. However, it is a fine solution to use for wiping the outsides or necks of cases clean, where you want them to look like new, factory "hulls."

Drying of Cases. Regardless of the method used for cleaning cases, they must be rinsed thoroughly and dried promptly, as otherwise they may corrode. Should any interruption interfere with the drying of cases immediately after they are cleaned, leave them immersed in clear water to keep the air away until they can be dried properly.

If the cases can be spread out in the hot sun to dry, boil them in clear water, dump them into a collander, then shake them well and vigorously to remove the excess water. Then spread them out in the sun to dry. The primer pockets are the hardest part to dry and the writer has been surprised to see how long it takes to properly dry cases, even in the hot sunshine of the tropics. One can help and hasten the drying of primer pockets by wiping them out with a bit of absorbent cloth on the end of a small stick.

The best and surest way of drying cases is with the use of artificial heat, but care must be taken not to overheat them, as too much heat will soften the brass and may render it incapable of withstanding normal pressures. Most modern stoves, whether electric, gas or coal, have oven thermometers that are, at least, fairly accurate. For stoves sold in the United States, these thermometers register degrees Fahrenheit and brass can be heated up to 428 degrees Fahrenheit without undergoing any change in its grain structure. For drying cases it is best to keep the temperature as low as 300 degrees. This heat is amply high for the purpose and offers a liberal allowance for any inaccuracy of the thermometer. If your oven has no thermometer, one can be purchased at small expense in almost any department or five and ten cent store. The thermometer should be placed near the cases as the temperature will not be the same in all parts of the oven. It is also well to place the cases on one of the sliding shelves or racks, away from the bottom
29 of the oven, or the heating element if it is an electric stove.

The sad ending to this little story about cleaning and drying cases is, that after you have spent several shekels for chemicals and thermometers and have spent a considerable amount of time cleaning and drying your cases, you will not have added a single thing to their usefulness for reloading. If, by chance, they have ever been fired with a mercuric primer you will certainly have done them some harm.

The Inspection of Fired Cartridge Cases.

In discussing the relation of cartridges to their chambers, it has been made clear (I hope) that more or less expansion of the case takes place when the cartridge is fired, and that this expansion makes the case fit its chamber more perfectly than it could be made to fit by any other means. It has also been shown that more or less longitudinal stretch may take place, with a consequent weakening of the case. Some of the defects that may occur from these causes have been illustrated and described. The question that will naturally arise in the reloader's mind and especially if he has had little or no experience with reloading ammunition is:—how can *I* find out what is happening to my cartridge cases when I fire them? The best that can be done here is to give methods for inspecting cases for some of the more important defects. To find the conditions is one thing and to interpret their significance is quite another, the latter requiring long experience and study.

Ignoring overloading to a degree that will cause a firearm to burst, the only danger in reloading ammunition lies in the use of cartridge cases that have been strained or weakened to an extent that might cause them to give way near the head when fired again. The case *must* be in good enough condition to hold the gasses in, and even with reduced loads a failure of the case near the head may cause eye burns of a painful nature or permanent impairment of vision. With this thought in mind, we will confine ourselves principally to those conditions that impair the strength of the cartridge case near the head.

30 After firing, the cases should be wiped off with a cloth to remove dirt and fouling on the outer surface, after which they can be examined for external defects. Those with splits or cracks should be discarded. In wiping off the cases, do not rub them too vigorously or twist them around with the cloth pressed tightly against them, espe-

cially near the head. Brass has the property of charging with dirt and grit, that is, particles of grit become imbedded in the surface of the metal and can not be entirely removed by any means. Also, if the cases are rubbed too hard, the cloth will pick up some of the surface grit which will act as an abrasive and polish the case nicely, but this polishing may destroy some of the markings that will give an indication of the case's condition. The surface of a fired cartridge can tell many stories to an experienced person.

Incipient or incomplete splits will show as slight wrinkles or depressions of greater or lesser length, running lengthwise of the case. If well forward of the solid head, they may be ignored. True, the case may split completely at this point the next time it is fired, but this will probably do no particular harm.

Incipient ruptures of the body appear as a mottled or wavy band or patch, or as a distinct irregular line on the surface of the brass. Their identification can only be learned from experience and careful observation but as they are of rare occurrence and, in the body of the case, are not dangerous, the reloader can ignore them.

Stretching of the case near the head is usually due to excess head space. This condition will usually, but not always, result in leaving a burnished band around the body of the case near the head. As the side walls are pressed firmly against the walls of the chamber while the powder charge is burning, any appreciable movement of the head to the rear will not only stretch the brass, but the latter, being in intimate contact with the chamber and under pressure, will usually be rubbed or ironed in such a way as to leave this visible band.

To really determine whether the case is weakened near 31
the head and the extent of the weakening, to examine the solid head for possible tears and to find out whether the primer contained mercury or not, it is necessary to section the case. Signs of excessive expansion near the head will suggest the possibility of torn brass but will not prove it. Neither will the examination of a single cartridge case prove that the condition is prevalent in all of the cases that come from one chamber, but if the condition occurs once it will occur again. Where the expansion of the case near the head is sufficient to tear the solid head at all, the cases from that chamber should only be reloaded with reduced loads and then only when the cases are *not* resized at the head.

To section a cartridge case for ordinary examination, fasten it in a vise by the rim. Any slight compressing of the rim will do no harm for this purpose. With a fine toothed hack saw, carefully saw the case down through the center. The straighter you saw, the less filing there will be to do later. A hack saw will not cut smoothly unless the thickness of the metal being cut is at least equal to the distance between two teeth on the saw, and as cartridge case walls are usually thinner than this, the saw has a tendency to rip or tear its way through the metal. This can be avoided by using a fine saw, then inserting as large a stick of wood as possible into the case, sawing through case and wood at the same time. The wood helps to retard the saw and makes it easier to control the cut. As the thicker portion of the case is reached towards the head, the cutting will become easier and smoother. As a matter of fact, as long as only the lower part of the case is to be examined, the upper part may be sawed off before the case is sectioned. Cutting through the last fraction of an inch of the head may be a little troublesome but it can be done by removing the case from the vise and rubbing it back and forth by hand, with the cut straddling the saw blade. When sawed, one or both halves of the case should be filed by placing the sectioned surface against the face of a bastard file and rubbing it back
32 and forth with the fingers. When the saw marks are filed out, transfer the specimen to a piece of very fine emery or crocus cloth placed on a flat smooth surface and rub it in a direction diagonal to the file marks, until the burrs left by the filing come out. It is unnecessary, for this purpose, to bring the sectioned surface to a high polish but regardless of the degree of polish, there will always be a rubbed skin of brass over the surface that can only be removed by etching. This surface skin must be removed, as it may cover up defects.

To etch the case, immerse it in a 20% solution of nitric acid for a few seconds, or until the polished surface takes on a dull or slightly roughened appearance all over. Do not use too much acid, or the brass will become pitted and pock-marked. When etched, remove the specimen with a pair of tweezers and rinse it in clear water. The action of the nitric acid will clean the fouling from the inside of the case thoroughly and if the surface has a silvery appearance, it is a sure indication that the case has been fired with a mercuric primer. This silver looking coating, which is really mercury, will disappear into the brass after the specimen has stood a little while, so the condition should be looked for immediately after taking the case out of the etching solution. Unfortunately, the failure of the mercury to appear does not always offer assurance that the case has never been fired with a mercuric primer, but the mercury will usually show up.

If the expansion at the head has been sufficient to tear the brass in the solid head, the breaks can usually be seen with the naked eye and certainly with an ordinary magnifying glass.

Any stretching of the side walls, due to excess head space, will show up in a reduction of the thickness of the side walls and an annular depressed ring in the brass just in front of the head. If the condition is not severe, that is, if the stretching has only caused a slight reduction in the thickness of the case wall, with no signs of breaking, and
33 if there are no signs of mercury, and if there are no tears in the head, the cases from that chamber and of that particular lot of cases may be reloaded with ordinary full charges, provided they are not resized so as to set the shoulder back at all. This applies to both rimmed and rimless cases. With a rimmed case this means that the reloaded cartridge will be positioned in the chamber by the *shoulder* instead of the rim, as normally, but the head will be in contact with the bolt when it is fired and any further weakening or stretching of the case near the head will be due to spring in the bolt itself or to a forward extrusion of the brass under the thrust of the gasses. One can check on this by reloading and firing two or three cases a few times, sectioning them as described and comparing them with the original sample.

Another point worthy of inspection is the primer pocket. The heads of fired cases should be examined for signs of gas leakage around the primers. Any cases showing black gas smudges radiating from the edge of the primer pockets should be discarded, as the primer pockets have either expanded or have some defect which permits gas to get past the primer cup. The primer cup acts in the same way the case does in the chamber. The side walls of the primer expand to prevent gas from leaking out between it and its pocket, but sometimes the pressure is sufficient to expand the pocket or some defect will permit gas to get by. A little gas will get past the primer, but ordinarily not enough to be noticeable to the shooter. An examination of the face of the bolt of any rifle that has been fired extensively will show the presence of a ring around the striker hole. Whether caused by erosion, corrosion or a combination of the two, this ring has its origin in the gas that, in small quantities, has leaked past primers. If, when decapping cases, a primer comes out with practically no pressure at all, it is a pretty good indication of an expanded primer pocket and that case should be discarded. If, in seating new primers, a primer goes into a pocket with little pressure, it *may* be due to an enlarged pocket and it may be a small primer. 34
Trying another primer will tell the story. If all the primers go into the primer pockets too easy, it can be due to the primers being too small. This is an unusual occurrence but happens occasionally, especially if the primers are not of the same make as the cases. Expanded primer pockets are an indication that the charges are developing pressures too high for the cases to stand and where this condition is found, the reloader should heed it and reduce his powder charges accordingly.

The Vent. The vents or primer flash holes in cartridge cases are made of a size correct for the primers with which they are loaded at the factory. The size of these flash holes may differ in different makes of cases and, more rarely, in different lots of cases made by the same manufacturer. Where one has a miscellaneous collection of cases, it is well to decap them all and examine the vents. Visual inspection alone will enable one to detect any material difference in the sizes of the vents, and to separate the cases into groups according to the vent sizes. Variations in vents will cause variations in the ignition of the charges, which will affect accuracy and with maximum charges may cause trouble if the vents are too large for the primers being used.

This condition is of increasing importance where the newest non-corrosive primers are being used.

At the same time that the vent sizes are observed, one can inspect the primer pockets for the presence of fouling or primer "ash." The fouling from our modern non-corrosive primers takes the form of a hard, brittle substance. It is sometimes present in sufficient bulk to prevent primers from being seated flush with or below the surface of the head of the case, and with some primers will afford a sufficient cushion to the blow of the firing pin to affect the ignition. This fouling is easily removed with a bit of cloth over the end of a small stick with a flat end, even running a pointed nail or decapping pin around the bottom edge of the primer pocket will chip most of it out.

Resizing Cartridge Cases.

The mechanics of resizing cartridge cases is simplicity itself. Some reloading tools have facilities for the full length resizing of cartridge cases and, according to the directions that come with these tools, the cases should be resized full length each time they are reloaded. Now, I have no desire to discredit anyone's statements on this subject. Cartridge cases can be resized completely most of the time, with no other ill effects than a slight loss in the accuracy of the reloaded ammunition, but we have already seen that the complete resizing of an over expanded case may be attended by some danger and in the interests of both the finest accuracy, as well as safety, it is recommended that cartridge cases not be resized any more than is necessary to their proper functioning. In using a reloading tool that is equipped with a full length resizing die, it is not necessary to force the case all the way into the die when operating the tool. Using the tool in this way prevents the shoulders of stretched cases from being set back to their normal position and also avoids any reduction of the case near the head when it is over expanded. At the same time, it does permit the neck to be resized sufficiently to hold the bullet and any slight reduction of the forward part of the body of the case will do no harm under any circumstances.

The hand resizing dies are quite convenient and useful, and cases can be resized completely by driving them in until the heads are flush with, or the rim is in contact with the surface of the die. The cases are driven out by means of a steel punch furnished with the die. In driving cases into the die they should never be struck directly with the hammer or mallet, but should be started in with the fingers and a block of hard wood placed against the head, this latter should then be struck with the hammer to avoid damage to the case.

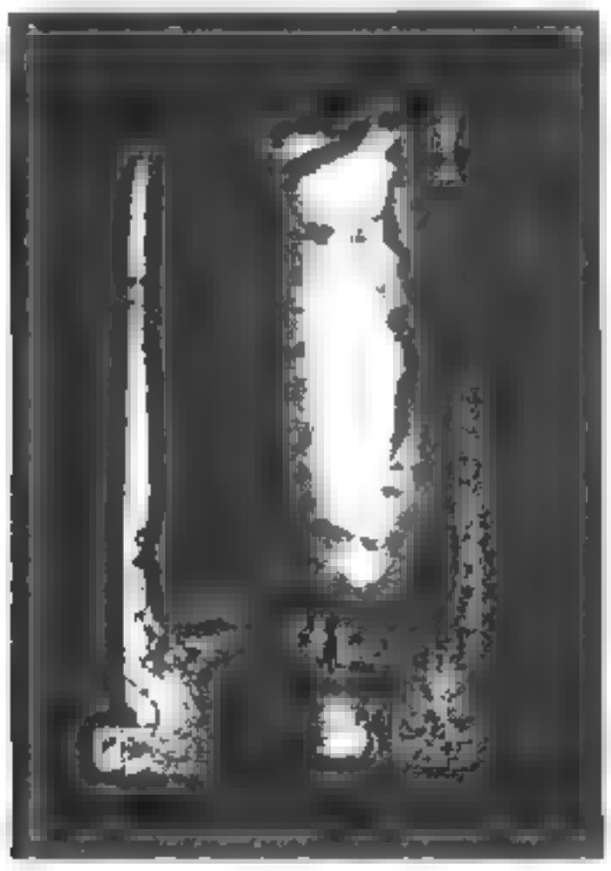
The vents in primer pockets are made by punching the metal out, and as the punches are small they wear quite rapidly. As their edges get a little dull, the holes are not
36 punched cleanly, more or less of a burr being left around the edge of the hole, on the inside of the case. If a flat faced punch be used to drive cases out of the resizing die, this burred edge will be flattened, reducing the size of the vent. Uniform vents are essential to uniform ignition of the powder charges, so when driving cases out of the die the knock-out punch should always be concave on the end that is inserted in the case so it will not bear on the metal near the vent.

As the complete resizing of cases is not ordinarily desirable, they should only be driven into these hand resizing dies far enough to accomplish the desired result; the desired result, by the way, being to reduce the case only enough to permit it to enter and to be extracted from its chamber without sticking. For partial resizing of cases, the hand dies are not as convenient as those which are mounted in reloading tools, also the exact depth of the resizing can not be controlled quite as well.

When cases are to be reloaded without resizing them, otherwise than at the necks, they should first be tried in the chamber of the arm they are to be used in. If they can be

entered in the chamber and the action closed on them completely, without forcing, they will also enter satisfactorily after they are reloaded. If you have a lot of cases that have been picked up on a rifle range and have been fired in rifles other than your own, you will probably find more or less of them that will not enter your chamber. This is due to the individual differences in the chambers of different rifles of the same caliber. Those cases which do not enter properly will have to be resized to a point that will eliminate the tendency to stick. When a case sticks in a chamber before the locking surfaces of the action are engaged with one another, it is a simple matter to knock it out with a cleaning rod. If the case sticks with the action nearly closed, the situation may be a bit embarrassing for a moment. The usual procedure under these circumstances is to curse and tug or hammer on the bolt or lever of the rifle, in the hope that the extractor will not slip but will pull the case out. 37
Sometimes it does and sometimes the extractor strips off the rim, permitting the case to be poked out with a cleaning rod. The best way to get such a case out, without danger of damage to the rifle or your disposition is as follows:

Note difference in head thickness and interior shape of these .30 '06 cases. The same load will not give the same result in all of them.



Factory cartridge fired once in chamber having loose fit at head—Note torn metal at base which might prove serious with a rimless case.

PLATE III

There is always some clearance between the head of the case and the bolt when the extractor is pulling on the rim of the case, so force the bolt up or the lever down until the extractor is pulling properly, then hit the inside of the case a sharp rap with the cleaning rod. This will drive the case back into contact with the face of the bolt or breech block. Repeat the operation a couple of times and that case will come out without trouble.

Before attempting to resize any cartridge cases, they should be wiped off to remove any free grit or dust and then lubricated. A good way to lubricate them quickly is to make a flat pad of a number of thicknesses of cloth and tack it to a board. The pad should then be moistened with a good light oil, such as 3 in 1, after which a number of cases can be placed on it at one time and rolled with the palm of the hand to lubricate them. An excess of oil should be avoided. Vaseline rubbed into the pad is also good.

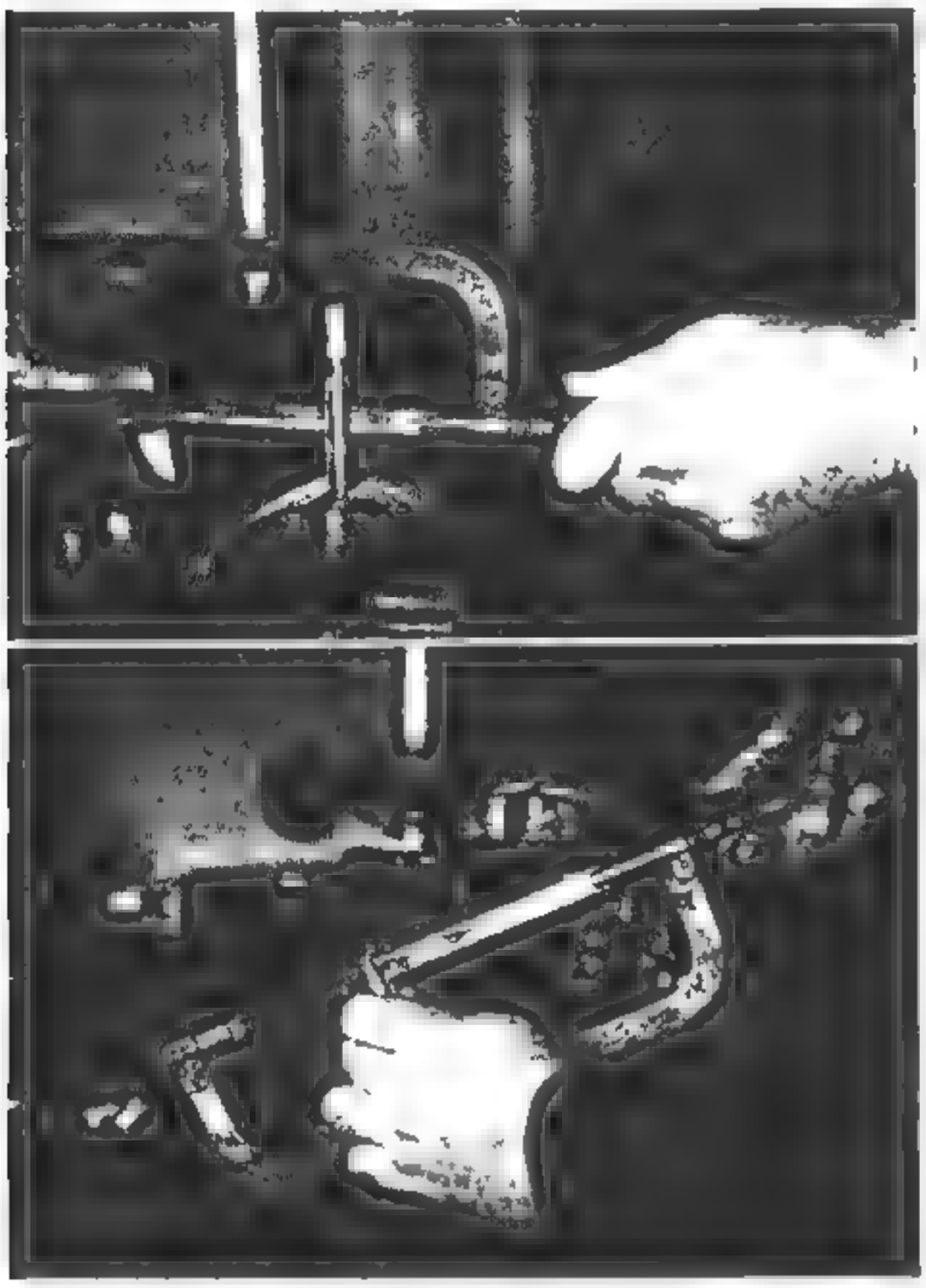
Cartridge cases fired on a range where the ground is sandy will charge with an excessive amount of grit, which will remain permanently imbedded in the surface of the brass. This grit will cause resizing dies to wear rapidly and will sometimes result in scoring them, after which that die will scratch every case sized in it. The manufacturer can usually polish it out for you without enlarging it enough to render it unserviceable, but a die can not be polished out more than once or twice at the most.

Now for a word about the dies themselves. Tool steel is, as its name implies, steel for making tools, but it is a general term applied to a *class* of steels and there are almost as many kinds of tool steel as there are kinds of tools. Most of them are not suited to the manufacture of resizing dies.
38 Those that are suitable for dies require careful heat treatment to prevent them from warping. If they are hardened, they become brittle and will break easily. If the hardened die is tempered or drawn to give it a tough structure, it will be softened and will not have a long life under continuous use. The best way to make a die of tool steel suitable for such a use is to "spout" them. When the die is heated to the proper temperature, a stream of water is run through the inside of it, chilling this inside quickly but cooling it more slowly toward the outside. This gives a hard inside surface, with a gradual softer and tougher structure toward the outside that will resist shock. But such dies would be expensive, as their manufacture would be slow and would call for the highest type of skilled labor.

High Speed steel is another misunderstood term. It also is a general term applied to a class of steels developed for making, cutting, turning and boring tools that will withstand the heat of running at higher speeds than are possible with tools made from the ordinary tool steels. High speed steels are tough and hard on the tools used to work them, but none of them are particularly well suited to the making of resizing dies. Pacific can supply their tools equipped with "high speed steel" dies. I have one of these and they do a very nice piece of work on the dies, but if they properly pack harden their carbon steel dies, and I have no doubt but that they do, I would prefer the carbon steel dies.

Carbon steel doesn't mean much either, but the term is

applied to the ordinary run of steels of various carbon contents. The low carbon steels machine smoothly and tools used on them have a long life, but low carbon steel can not be hardened by the ordinary process of heating and quenching in oil or water. Dies made from it can be and are hardened by a process known as "pack hardening," which is similar to case hardening. This gives the inside of the die a very hard surface, a harder, more durable surface than a drawn tool steel die or a high speed steel die, and at the same time a good resizing die can be made in this way at a moderate cost. 39



Method of sectioning fired cartridge case to prepare it for etching.

PLATE IV.

Neck Resizing. The expansion which takes place in the necks of cartridge cases when they are fired leaves the necks so large that new bullets will usually drop right through them. If the cartridges were crimped before they were fired, the crimp will not "shoot out" entirely and the mouths of the cases will have enough crimp remaining to offer an obstruction to the entrance of new bullets. This remaining crimp must be removed, so it is often desirable and sometimes necessary to resize the cases at the necks, before attempting to seat new bullets.

Neck resizing is *necessary;* when the reloading tool operates with the case in a vertical position, in order to keep the bullets from dropping inside during the seating operation; when jacketed bullets having no crimping grooves or cannelures are used; and when cast bullets either have no crimping grooves or are seated to a depth that leaves the mouth of the case at a point on the bullet inconvenient for crimping. If the bullets have crimping grooves conveniently located, excellent ammunition can be reloaded without resizing case necks at all, provided the design of the loading tool will permit this method of loading. Ammunition so loaded will be found to have the bullets more or less loose, and they can always be turned around with the fingers. This does no harm from an accuracy standpoint and is often an advantage but, as a rule, it is desirable to resize the case necks in order that there will be no chance of the bullets coming out in the ordinary handling and loading of the ammunition.

If the cases are resized full length, the necks will be reduced at the same time, and some loading tools will also expand the necks to the proper diameter to receive and hold new bullets at the one operation.

Resizing case necks is divided into two operations; the reduction which should be sufficient to make the inside diameters of the necks a little too small, and the expansion 40 which opens them up to the correct diameter. This procedure is followed in the manufacture of new cases also, the expanding operation being known as "ball sizing." It is necessary because, due to differences in the thickness of the brass in the walls of case necks, it is impracticable to bring the *insides* of the necks to the correct diameter by simply resizing the *outsides.* Even cases of the same make and lot will vary in thickness at the necks, also the thickness will not be uniform all the way around the necks, except by chance. The temper of the brass also has a material effect upon the way the necks resize. All other things being equal, hard brass will spring back more than soft brass after the necks are either reduced or expanded.

In order to produce neck reducing dies, or "muzzle resizers" as they are generally called, economically, manufacturers of loading tools must make one standard size for each caliber of cartridge. These are made of a size that will reduce the thinnest cases sufficiently and as a consequence they will reduce cases with thicker necks a little too much; or more properly, a little more than is necessary. This does no serious harm but it will shorten the useful life of the cases, especially if the brass happens to be harder than

Expanding plugs of different diameters may be obtained to meet the requirements of the bullet being loaded. The general rule is to use an expanding plug that is the same diameter as the bullet. As the brass springs back slightly after the neck has been forced over the expanding plug, its inside diameter will actually be one or two thousandths of an inch smaller than the plug or the bullet, and the latter, when forced into the neck, will be held firmly by the tension of the brass.

Another way to expand necks and one that, if followed, will overcome most of the difficulties that may be encountered with this operation, is to use an expanding plug that is a thousandth of an inch or two *larger* than the bullet. This plug should only be forced into the neck about one-

third the length of the seating depth of the bullet. This 41
will expand the mouth of the case so that the bullet can be set into it perfectly straight and for a sufficient distance so that there is no possible chance of its tipping. The seating is completed in the tool, the bullet acting as its own expander for the remaining distance. Even cast bullets with plain bases may be seated in this manner, and there will be no chance of their being scraped or shaved during the operation. Some cases, the .22 Hornet being a notable example, have very thin necks and sometimes bullets can not be seated friction tight except by the method just described. As it takes much less force to expand the thin walls of a case neck than it does to compress a lead bullet, this method of expansion will be found satisfactory with any kind of bullet.

Bullet Pull. When commercial or military ammunition is loaded, it is subjected to a test to determine the amount of force or pull required to draw the bullets out of the cases. This is done to insure that the bullets will not come out from handling, or loading and extracting the cartridge from an arm. There is a minimum pull allowed, below which the ammunition would not be satisfactory, but as long as the bullets can not be pulled out too easily, it generally doesn't matter how tight they are. It is commonly believed that a variation in the tension under which bullets are held in place makes a great deal of difference in the way the ammunition shoots, also that a cartridge in which the bullet is held very tightly will develop a much higher pressure than a similar cartridge with a looser bullet. Perhaps there is some slight difference, but from a practical standpoint it doesn't amount to a hill of beans. Bear in mind that we are speaking now of the tension of the neck on the bullet and not of crimping, which will be discussed later.

No one knows positively what takes place inside of a cartridge when it is fired, but by observation of some of the known factors it is possible to make deductions that are logical and probably correct. When a powder charge 42
starts to burn, gasses are formed which, being confined, build up pressure inside the case. The pressure starts from zero and increases as more and more of the powder catches fire. Due to the weight and inertia of the bullet, it does not start forward into the bore at once. As the walls of the cartridge case are thinner and weaker at the front than at the rear, and as it requires less time and pressure to expand the thin neck of the case than it does to start the bullet forward, the case lets go of the bullet, allowing more or less of the gas to escape past it. As the pressure increases, the inertia of the bullet is overcome and it moves forward into the bore, practically sealing the bore and preventing further escape of gas. If the case lets go of the bullet before the latter starts forward, leaving it free and floating around by itself as it were, how in the name of common sense is a few pounds difference in the force required to pull a bullet out of a case going to have any retarding effect upon the forward movement of the bullet when the cartridge is fired?

Tight Chambers.

Some custom made barrels are purposely turned out with exceptionally tight chambers, in order to improve their accuracy. It is necessary to distinguish between minimum chambers and tight chambers. The former is the smallest chamber that is considered permissible in commercial or military arms, while the latter are smaller even than a minimum chamber; so small and tight in fact that commercial ammunition will not always enter them. In making cartridge cases for use in tight chambers, commercial cases are used but they are re-reformed so as to fit the chambers perfectly, the necks being turned on the outside to eliminate the inequalities in thickness of metal and to make the outside concentric with the inside. Their outside neck diameter is usually an exact fit for the neck of the chamber.

When such a case is loaded and fired there is no expansion of the neck and consequently, little or no gas
43 escapes past the bullet during the interval between the time the powder starts to burn and the bullet starts forward to seal the bore. There is also very little expansion of the body of the case. As *all* of the gasses are confined within a rigid cavity (by rigid is meant that there is no cushioning effect from the initial expansion of the case) and as the chamber is of smaller volume than normal, the pressures developed in a tight chamber will be higher than if the same cartridge and load were fired in a commercial chamber. But tight chambers are impractical. Cartridge cases often require more than ordinary force to extract them, at least to a degree that is not permissible in hunting and military arms; and besides, it is impractical to maintain such a close relation between cartridge and chamber in commercial production. Nevertheless, a condition approaching that of the tight chamber is sometimes found in a few commercial arms and ammunition, notably in the .220 Swift and the .257 Roberts. In these calibers, the difference in size between a maximum cartridge and a minimum chamber is hardly more than .001 inch. It is of course, slightly more between a maximum chamber and a minimum cartridge, but the tolerances are remarkably close.

The normal performance of ammunition in these calibers contemplates enough expansion at the neck of the case to let go of the bullet. If, for any reason, the necks of the cases can not expand, the chamber pressures will increase to an abnormal point and may be dangerous. It has been pointed out that sometimes there is a forward movement or extrusion of the brass in a cartridge case, probably due to the thrust of the expanding gasses. In an ordinary chamber, the thickening of the case neck which results from this is insufficient to prevent the neck from expanding and letting go of the bullet when the case is reloaded, but in chambers having tight necks the situation is different. A little added thickness at the neck may be enough to cause excessive pressures.

For this and other reasons the writer believes that the
44 reloading of cartridges of the calibers mentioned, or of any caliber where the neck of the case is a very close fit in the neck of the chamber, should not be attempted by the novice at reloading if full charges of powder are used. In fact, the beginner had best keep to reduced charges with any caliber of ammunition until he has acquired experience, and has learned something more than the mere mechanics of assembling ammunition.

The resizing of cartridge case necks for chambers with

close tolerances differs from the usual perfunctory reducing and expanding of the case necks. Where a chamber is known or believed to be unusually tight at the neck, this part should be carefully measured. Directions for making sulphur casts for this purpose are given elsewhere in this book. After determining the size of the chamber neck, proceed as follows: Reduce, or reduce and expand, the necks of the cases until their *outside* diameters are at *least* two thousandths of an inch (.002") smaller than the neck diameter of the chamber. If a greater reduction than this is necessary to leave the insides of the necks small enough to hold the bullets, so much the better. When your cartridges are loaded, measure the necks of *all* of them and set aside any that are not *at least* .0015" smaller at the neck than the chamber neck. The bullets should then be pulled from these cartridges and the insides of the case necks reamed out until they can be sized to hold the bullets without enlarging the outside neck diameter too much. Don't make the mistake of measuring but a few of your cartridges and assuming that the rest are like the ones measured. These thick necks only occur once in a while, and while you may never encounter one, they are of sufficient importance to watch out for. Their occurrence is not limited to any particular calibers and the condition is *only* of importance in chambers having tight necks.

Chapter Two

45

PRIMERS.

The handloader should understand that the primary function of a primer is to ignite the powder charge promptly, adequately and *uniformly*. What the primer may be made of, or any other special properties it may have in addition to its ability to ignite the charge, are incidental and of secondary importance. Emphasis may be placed upon ignition properties of a primer to the same degree that it is placed upon the function of the cartridge case as a gas seal. Both are fundamental.

The type of primer that we are most familiar with today and the one to which we will devote the most attention, is composed of three principal parts; a metal cup, a pellet of explosive priming compound which is pressed into the cup, and a metal anvil against which the priming compound is driven by the firing pin to explode it. This type of primer is a product of evolution and to understand the reasons for this type of design, its virtues and its limitations, it is necessary to know something of the general types which preceded it.

Our Civil War was fought for the most part with muzzle loading arms which were fired with percussion caps. These caps were made in a number of forms, but the most common and the best took the form of a thin copper cup having the priming compound pressed into it and usually covered with a thin disc of tin foil. This fitted tightly over a steel nipple on the barrel, with the priming pellet in contact or close to the top of the nipple. The nipple was provided with a hole leading to the powder chamber and its upper edge was flat. When the hollowed face of the hammer struck the cap, the pellet was pinched between the bottom of the hammer cup and the flat surface of the nipple, causing it to explode. The flash produced passed on to the charge, igniting it. It will be seen that this system had all the elements of our present day primers; a cup, a priming pellet and an anvil against which the pellet was exploded.

46

The demand for arms during the Civil War period and especially for arms that could be reloaded more rapidly than the muzzle loaders, led to the development of the breech loader, the metallic cartridge and the repeating rifle, many novel breech loading systems making their appearance in rapid succession. The first practical repeating rifle was the Spencer, which used a rim fire cartridge of large caliber.

Rim fire cartridge cases are made from thin metal and in folding or forming the rim, a space is left into which the priming mixture is "spun," forming a ring of priming around the rim of the case. The firing pin must strike the cartridge at the rim in order to pinch the priming and fire it. This type of priming is unsatisfactory in large caliber cases. The ring of priming is brittle and structurally weak and in the ordinary handling and loading of the cartridges, pieces of priming break away, leaving dead spaces which, if struck by the firing pin, will result in mis-fires.

A lot of muzzle loading arms were converted to take the then new metallic cartridges and the design of some arms made it easier to convert them to fire a center fire cartridge. One type of center fire cartridge that enjoyed a short period of popularity was made with an internal primer. The case itself looked like a rim fire case and the primer was in the form of a pellet, crimped into the base of the case, on the inside. But this type of case was *not reloadable*. The reloadability of ammunition and the people who have reloaded it have had a great influence upon the development of our ammunition, not only in the past but at the present time as well. Many a reloader with a little time and money at his disposal, plus the ability to experiment intelligently, has contributed to the development of factory loaded ammunition. Cartridges were expensive in the early days of the ammunition industry and money was scarcer than it is today, consequently the reloadability of ammunition was important to the owner of any firearm. Even today there are

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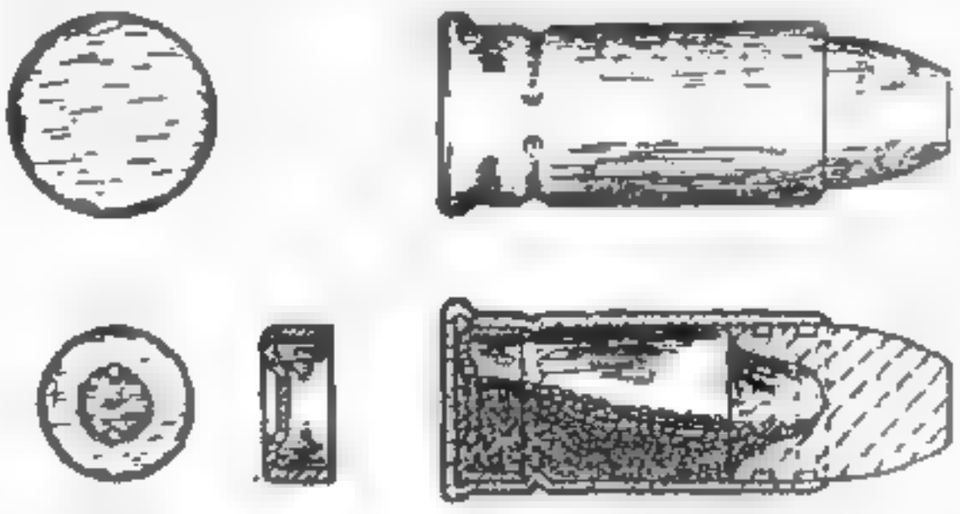

An early center fire cartridge—made with an internal primer.

thousands of shooters who, because of the expense of factory ammunition, would never purchase firearms were it not that they can easily reload their fired cartridge cases with a few simple tools and thus provide themselves with an abundance of ammunition at small expense.

The immediate forerunner of our present primers was what is commonly termed the "Berdan" primer, named after

its inventor, a Colonel Berdan of the Union Army. This primer takes the form of a cup similar to that used in our present primers. This cup contained the primer pellet but had no anvil. The anvil was formed in the bottom of the primer pocket and was part of the cartridge case. Flash holes or vents were drilled at the base of the anvil and were usually two or three in number. The Berdan primer has certain points in its favor, perhaps the principal of which is that the anvil in the primer pocket, being of solid brass, is more rigid and offers greater resistance to the blow of the firing pin than the separate bent metal anvil which we now use. But from a reloading standpoint the advantage is all the other way. Berdan primers are used almost exclusively in European ammunition, but it should be borne in mind that firearms were never used as extensively by the general population of European countries as here in the United States and consequently reloading has never attained the wide spread popularity that it has here. Europe was, as it is now, a collection of settled countries with fixed frontiers (as long as the politicians left them alone) while in the United States the condition was different.

48

At the time when firearms and ammunition were undergoing their most rapid development we were a new nation; one that had been hacked out of a wilderness and one in the development of which firearms had played a most important part. Furthermore, at that particular period, we had a rapidly expanding frontier towards the West, where firearms in the hands of the settlers were indispensible tools. Our ammunition problem was different from that of Europe and the problem of reloading fired cartridge cases was an important part of it.

The Berdan primer did not meet the requirements of the reloader satisfactorily. The anvil in the center of the primer pocket, with small vents around it, did not permit easy expulsion of the fired primers. They could not be forced out from the inside but had to be dug or pried out from the outside, which was inconvenient. The vents were small and were easily clogged by fouling or corrosion, the latter sometimes forming after the ammunition was reloaded. The early folded head cases had anvils that were merely pressed into shape, these were not of solid brass and a long firing pin would deform them and reduce their height. However, black powder is easily ignited and minor damage to Berdan anvils did not have any appreciable effect upon ignition. The objection to the Berdan primer from a reloading standpoint was chiefly a mechanical one, but with modern smokeless powders any damage to the anvils, whether from corrosion, erosion, or mechanical causes, will affect the order of explosion of the primers. Any lack of uniformity of the anvils will result in variations in ignition and, consequently, in muzzle velocity. Early attempts were made to overcome the difficulty of decapping cases by providing a central hole through the anvil, sometimes by itself and sometimes with vents at the base of the anvil as usual. The single flash hole through the anvil was unsatisfactory. In the first place, this design removes the support from the place it is needed most, that is, right under the point of the firing pin. In the second place, the flash produced by the primer was limited to that produced in the immediate vicinity of the flash hole, the indentation of the cup practically closing the vent. With

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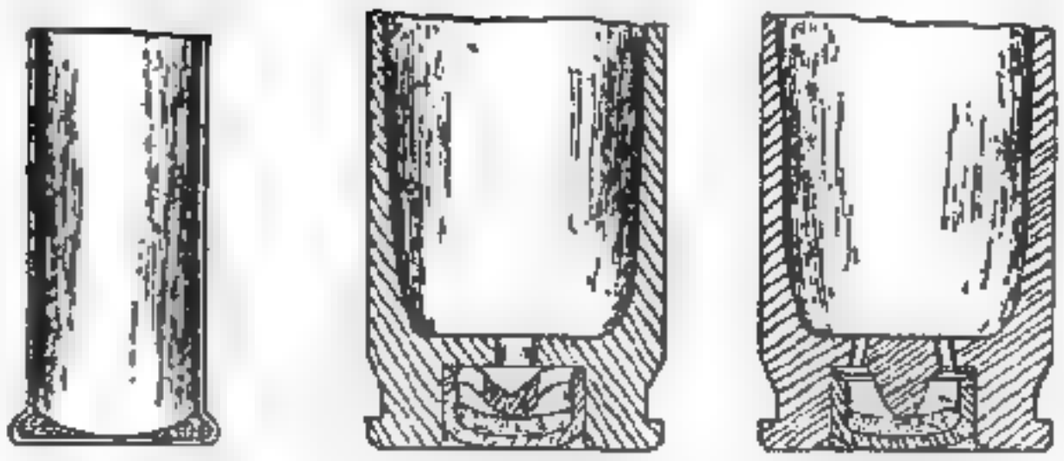

RIM FIRE SEPARATE ANVIL PRIMER "BERDAN" PRIMER

other vents at the base of the anvil the ignition was improved, but the central vent still failed to give sufficient support to the pellet and the anvils were subject to the same rigors of repeated firing and reloading. This idea of putting a central vent in a Berdan primer anvil has been "rediscovered" a number of times during the past sixty years, but it is fundamentally wrong and thus far has always ended up a failure. It does permit primers to be forced out from the inside of the case with the conventional decapper having a pin on the end for the purpose, but that is about the extent of its rather questionable advantage.

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Now let's take a look at the American type of primer in comparison, with its separate anvil assembled with the primer and one central flash hole in the primer pocket. Let us grant that this anvil is less firm and more likely to collapse under the blow of a firing pin than the solid Berdan type. The superb accuracy we obtain with our match ammunition would seem to indicate that there was nothing wrong with the ignition and that the objection referred to was purely theoretical but the answer is, that our anvils are too *near* the line of being unsatisfactory. They do collapse to a certain extent, cushioning the blow of the firing pin; also, unless they are properly made and hardened by cold work, they can cause ignition difficulties. Very well. We will give the Berdan anvil the edge in *new* ammunition but *not* in reloaded ammunition. Our primers are easily expelled; the primer pockets offer no irregularities but are easily cleaned of fouling to give new primers a firm seat on the bottoms of the primer pockets, and as each primer has a new anvil incorporated in it, it is possible to get uniform ignition regardless of the number of times that a case is reloaded. So much for general types of primers.

The reloader can do no more than purchase primers and use them. He can't make them and he can't change the ones he buys, so at first glance, it may seem useless to say much about the way they were made. Nevertheless, the primer is the very heart of a cartridge and the use of an improper primer or one that is improperly seated can defeat all the pains and care that you may take in reloading ammunition. And what is an improper primer? Simply one that does not ignite powder charges uniformly and adequately. A primer that may be unsatisfactory with one load may be excellent with another charge of a finer or more easily ignited powder. Judging from an extensive correspondence with reloaders in this and other countries, the popular belief is that accurate ammunition depends upon extreme accuracy of powder charges and uniform bullet diameters and weights. Up to a certain point, yes, but primers can make a lot more difference in accuracy than any little differences

in the weights of powder charges, and reloaded ammunition 51
that shoots fairly well can often be made to shoot better, simply by changing primers. It therefore seems permissible to look closely at the way primers are made and why.

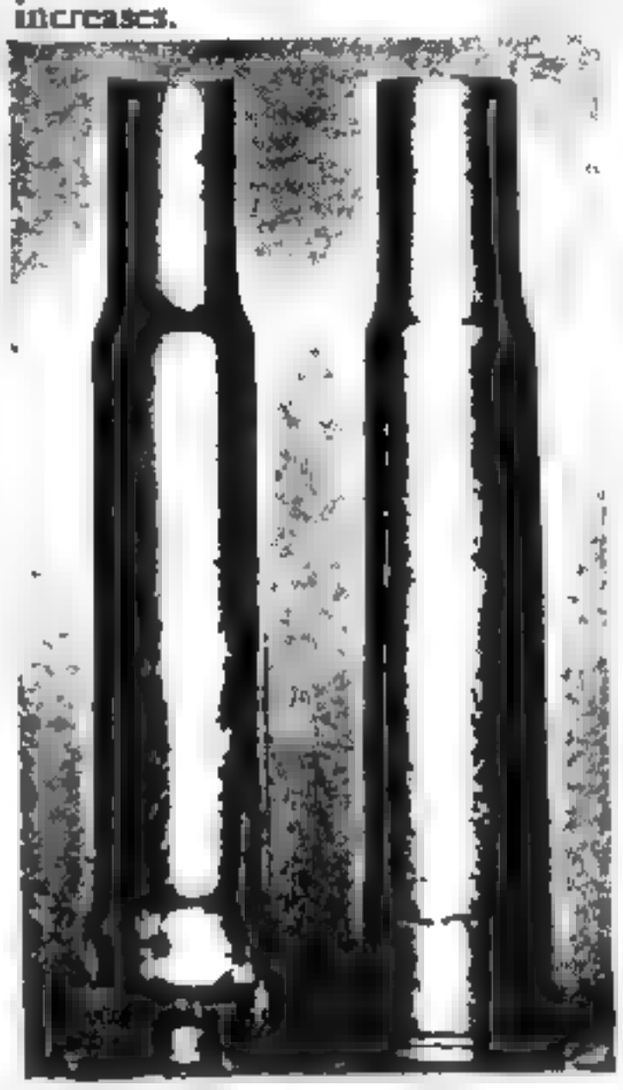
The Primer Cup. The function of the primer cup, in addition to holding the priming pellet, is to prevent gas from escaping to the rear. It functions in the primer pocket that same way that the case does in the chamber. Under pressure, the walls of the cup expand against the wall of its pocket, thus forming a gas seal. Primer pockets are not always perfectly round and even though primers seem to fit them tightly there is usually enough space somewhere around them to permit air or water to enter, therefore commercial and military primers are waterproofed after loading, by allowing a little varnish or lacquer to flow around the edges of the primers to fill these minute crevices.

The cups must be soft and thin enough to be properly indented by the firing pins of the arms they are to be used in, at the same time they must be strong enough to hold in the pressures developed within them. The sensitivity of the priming mixture influences the design of the primer cup also. Some mixtures require a harder blow to explode them than others, with such, a thick or stiff primer cup might absorb too much of the blow of the striker to cause a proper and uniform explosion. If a mixture could not be fired with a cup strong enough to support the pressure developed, that mixture would have to be discarded. Therefore, the differences in hardness that is found between primers of different makes is not a matter of chance but is the result of careful study and experimentation on the part of the manufacturers. A primer having a stiff or thick cup is not necessarily better than one having a thinner and softer cup, except that the former can be seated with less liability of deforming it in the process.

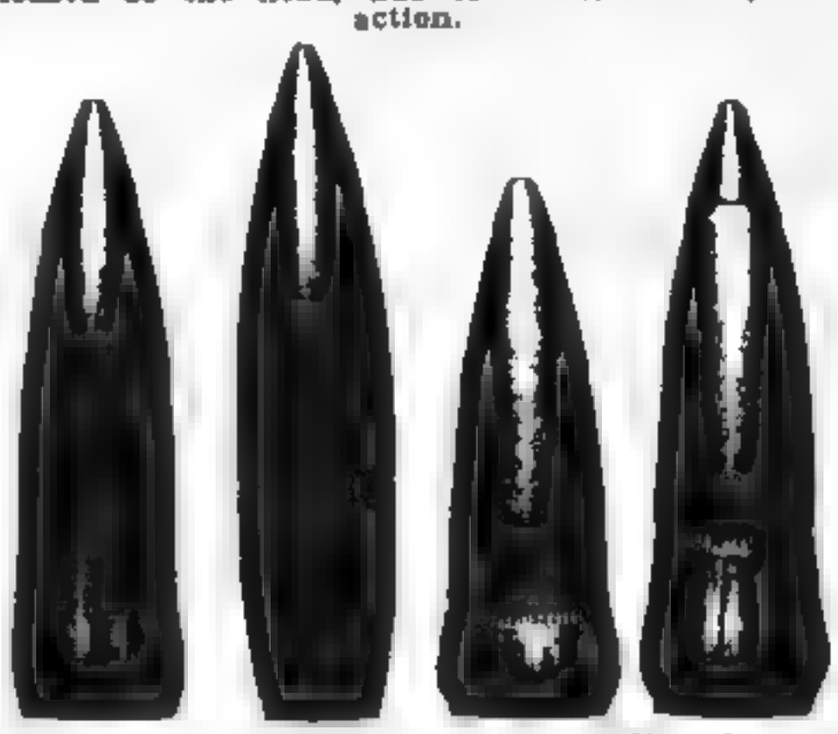
Generally speaking, primers for rifle cartridges are made with thicker and stiffer cups and contain more or hotter mixtures than primers intended for use in pistol and revolver cartridges. The rifle primers are made stiffer or thicker 52
because the firing pins of rifles usually strike harder blows than those of pistols or revolvers. Furthermore, the pressures built up inside of rifle primers are much higher than those developed in pistol primers so, if too thin or too soft metal is used in the cups, the primer will be pierced, permitting gas to escape through the action and possibly causing eye burns.

Pierced primers may be caused by too long or too sharp a firing pin, but the more common reason for them is failure of the primer cup at the point where it is struck. The cup is weakened where it is indented and if the pressure within the primer be too high, the weakened portion may blow back through the firing pin hole and permit gas to escape at the same time. When this happens, the striker or firing pin is blown back violently and may be damaged. Firing pin holes that have worn large or become eroded by escaping gas may not support the center of the primer sufficiently and may permit a circular piece of the cup to blow out. This condition can often be detected by examining fired primers and observing the area of that part of the primer which has set back into the firing pin hole, in relation to the indentation of the firing pin. There must, of course, be a little play around the firing pin in order to permit it to act freely and without sticking in its forward position, but the difference in the size of the hole and the firing pin should not be excessive. It is well also to examine the firing pin itself, as the trouble may be due to its wear rather than to the hole through which it passes.

The amount of pressure developed inside of the primer is influenced by the size of the vent. If the pressure within the case were maintained long enough, the primer pressure would be equal to the chamber pressure but the cycle of ignition and combustion is so short that there is not time for the pressure to equalize itself in these two cavities. In spite of this, the primer pressure will increase as the size of the vent increases.



Halved sections of a .30/40 case which has been fired with a mercuric primer, then polished and etched. This case had split and stretched at the head, due to excess head space in the action.



Showing upsettage of bases of flat base bullets in comparison with a boat-tail bullet which does not upset when fired. Upsettage depends upon the structure of the bullet, its hardness, the force applied behind it and the suddenness with which the force is applied.

PLATE V.

53 Cracks sometimes occur in the bottom of primer pockets. This defect is traceable to the use of mercuric primers and is, I believe, limited to folded head cases such as are used

in much of our present day revolver ammunition. As primers should never be seated without inspecting the primer pockets first, this defect will be easily observed. Its effect is to permit an excessive amount of gas to reach the primer, driving it back violently against the recoil plate of the revolver, setting back or cracking this part and necessitating sending the arm to the factory for repairs. The webs can be broken to an extent that will permit the primer to drive forward without firing at all, then again there may be enough resistance to cause the primer to fire. The broken web can permit a greater amount of flash than normal to reach the charge and cause over ignition of the powder, with attendant high pressure.

Some reloading tools have apparently been designed with more thought about speed of operation than the elementary principles of reloading, and the operations of decapping and repriming have been combined with no consideration whatever of permitting proper inspection of the primer pockets before seating new primers. Fortunately, all of these tools permit the two operations to be divorced from one another and the reader should be wary of the tool that doesn't.

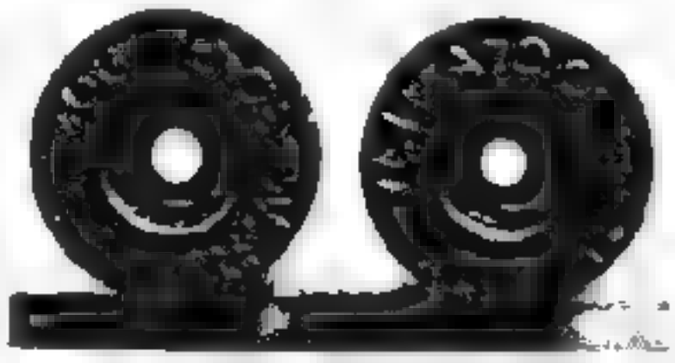
Primer Pellet. The primer pellet is the fire producing or business part of the primer and it is made from a mixture of several ingredients, as there is no one substance suitable for the purpose. Small arms primers are fired from the blow delivered by a firing pin and the force available is limited, making it necessary to use at least one substance in the mixture that is very sensitive to shock. This element which starts the burning of the primer is usually called the "initiator" and it must be a substance that will explode on receiving a sudden shock or blow from a firing pin. Its positive action depends upon a second, or frictional element, which is a rough, hard substance incorporated in the priming mixture. The third element is the "fuel" or that part of the mixture which produces the flame. This flame must 54
be of sufficient length and duration and must produce enough heat to ignite the powder charge properly. The priming compound, in its action, can be likened to a blue-tip match. The tip of the match is the initiator; the rough side of the box the frictional element, and the head of the match is the fuel which must burn long enough to ignite the wooden match stick. A different arrangement, but the same general idea. Some initiators produce a considerable amount of heat, but because of their quick, violent nature the heat does not last long enough to accomplish its purpose. Likewise, some frictional elements are good fuels, while others, notably ground glass do not burn at all but apparently become incandescent when the primer explodes and thus contribute in a way to the ignition of the charge.

It used to be believed that ground glass from primers caused a scoring of the throats of rifle barrels. The writer doubts this, for *if* the glass becomes incandescent, and there is evidence to indicate that it does, the hot particles would be too soft to score the barrel. Besides, ground glass is still used in some of our present day primers and long series of shots fired with such primers show no injury to barrels. It would therefore seem that the old prejudice against ground glass as a frictional element in primers was unjustified and that the scoring referred to was in reality due to erosion. Erosion has only become of interest to ballisticians in comparatively recent years and while what is known of it is largely from the standpoint of results rather than causes, it is certain that the condition is in no way dependent upon ground glass in primers.

Chlorate Primers. The first initiator used in small arms primers successfully was fulminate of mercury. As it is too quick and violent in its action to make a good primer by itself, it was combined with potassium chlorate, the latter being an initiator as well as a fuel. Both of these substances have formed the basis of primers for small arms up until only a few years ago and our military primers are still made
55 without fulminate of mercury, but with potassium chlorate as the principal ingredient. No primers are made with these two substances alone, others must be incorporated with them to produce good priming mixtures. Both chlorate and chlorate-fulminate primers are excellent from an ignition standpoint, but like all good things, there is some evil in them. Potassium chlorate primers, when fired, leave a deposit in the barrel that gathers dampness rapidly, causing rusting, therefore arms fired with these primers should be cleaned promptly after firing, preferably with water, as oil or nitro solvents that do not contain water will not dissolve this fouling.

Any primer containing fulminate of mercury is termed a mercuric primer; when fired, the mercury will attack the brass cartridge case and often render it unfit for reloading—and the reloaders never did like that.

All of these cases have some difference in vent size or bevel which would affect the ignition of the charge differently.



The vent site may be different in various lots of the same make and caliber of cartridge case.

PLATE VI.

Non-Corrosive Primers. For many years ammunition manufacturers have been experimenting with other initiators, in an effort to get away from the corrosive evils of potassium chlorate, so a few years ago the first of the so-called non-corrosive primers made their appearance. The term "non-corrosive" as applied to these primers is a misnomer as many of them will, by themselves, leave a deposit on steel that will cause rusting to a greater or less extent. When properly made, and loaded so that the products of combustion from the primer are combined in proper proportion with the other products of combustion, the *ammunition* is non-corrosive and the fouling from it will not rust the barrel. The production of non-corrosive ammunition requires a study of *each* caliber and loading of cartridge, as the quantity and composition of the primer mixture must be governed to produce both good ignition and non-corrosive properties.

The great majority of non-corrosive primers being loaded in factory ammunition at this time contain fulminate of mercury and the one manufacturer who has been loading non-mercuric primers is swinging back to the use of fulminate of mercury. Why? Because fulminate of mercury 56
produces heat and its use in these primers makes them better igniters, without destroying the non-corrosive properties.

The non-corrosive primers sold for reloading purposes do not contain fulminate of mercury and while they are of the so-called non-corrosive variety, they can not be depended upon to be entirely non-corrosive in their action because of the inability of the handloader to control the products of combustion of the powder charge to produce this effect. They will be less corrosive than the old chlorate primers but the wise shooter will do well to clean his guns after shooting them when using reloaded ammunition. Of course the *wise* shooter cleans his guns after shooting any kind of ammunition, so that admonition is probably superfluous.

Another thing to watch out for is the mixing of non-corrosive primers, that is, firing more than one brand of primer without first cleaning the bore thoroughly. Each manufacturer has his own primer formulas and they do not all use the same ingredients in their primers. The products of combustion of two different makes of primers, if mixed, can and may cause rapid rusting of the barrel

Mercuric Primers. A mercuric primer is *any* primer that contains fulminate of mercury, regardless of what other properties it has. When a cartridge case that has been fired with a mercuric primer is reloaded and fired again, the brass will crack to a greater or less extent. These cracks may be very minute internal cracks, but once they open up they permit the mercury to penetrate deeper into the brass and it is only a question of time before the case will crack completely through. The illustration on Plate X shows an automatic pistol case that has been fired to destruction. This case was originally loaded with a mercuric primer, then was reloaded and fired three times with primers that did not contain fulminate of mercury. The result shown in the picture was brought about by the mercury in the primer with which the cartridge was originally loaded. It will be readily understood that had this condition occurred with a 57
rifle cartridge loaded with maximum loads, the result would have been serious for the gun.

Because of the low pressures developed in pistol and revolver cartridges, mercuric primers are not a source of danger in the ammunition used in them when loaded with reduced or even normal loads. The damage that they do is usually limited to the ruination of the cases after they have been reloaded a few times. This is not true of ammunition reloaded with maximum or excessive charges, although when a handgun lets go the damage is principally confined to the gun and the hand holding it.

Primer Anvil. Primer anvils are made of hard worked brass, that is, they are made as hard and stiff as possible without being brittle. Their form has much to do with the performance of primers and they are made so they will serve their purpose even though the firing pin does not strike precisely in the center of the primer. As both factory ammunition, and reloaded ammunition the cases of which have been resized, are a trifle loose in the chambers of arms, the cartridges naturally lie in the bottoms of the chambers. The firing pin holes are opposite the centers of chambers and this frequently causes the firing pin to strike above the center of the primer. Looseness in the firing pin itself may also cause it to strike off center. This can be considered as a normal condition under the circumstances mentioned and primers must function with reasonable satisfaction under such condition. Theoretically, it is an undesirable condition and can be at least partially avoided by using cartridge cases that have not been resized near the heads. Just how much practical difference in ignition may be caused by the off-center blow of the firing pin this writer does not know but it must cause some slight difference, at least if the condition is aggravated. Otherwise the anvil form would be a matter of small consequence.

When anvils are forced into the primer cups, they are left flush with or projecting slightly beyond the edge of the cups.
58 They are never below the edges of the cups. This is done to permit the anvil to rest firmly upon the bottom of the primer pocket, so it will form a solid support to the blow of the striker. If, for any reason, the anvil is not so supported, the blow will be cushioned and the primer will not deliver its full efficiency.

Seating Primers.

This is one of the most important operations in loading ammunition for, granting that the primer is suitable for the cartridge and load, failure to seat it properly will defeat all the care that has been used in the manufacture of the primer and the loading of the ammunition. The present non-corrosive primers sold for reloading purposes are pretty good igniters, but they have some characteristics that make it imperative to seat them carefully in order to get uniform ignition.

The older chlorate and chlorate-fulminate primers were made with wet priming mixtures. The ingredients were mixed with a gum arabic solution to increase the safety of loading and the pellets, when dried out, had slightly elastic properties, due to the gum binder. These primers could and can be seated with quite a heavy pressure without breaking the pellets, and ammunition loaded with them will shoot quite well, even if the primers are seated with sufficient pressure to mash the cups flat. Not that I recommend this

however. Excessive pressure will increase their sensitivity as a rule, and while some variation in ignition must occur when the pressure of seating them is not uniform, they are no where near as temperamental as the newer primers.

Most of the non-corrosive primers are loaded with a dry mixture and the pellets are formed only by the pressure applied to them. These pellets are brittle and are easily broken if too much pressure is applied to the primers in seating them. More than one lot of factory ammunition has been broken down and loaded over again, because the priming machines exerted a little too much pressure in seating primers that had been previously tested and found satisfactory. Naturally, it only takes one experience of this kind 59
to put a manufacturer on his guard against a recurrence, but the reloader, using hand tools and miscellaneous cases that do not all offer the same resistance to the primers when they are seated, must be especially careful with this operation.

Some reloading tools seat primers by means of a powerful lever, the leverage being excessive for the purpose. Such tools must be used with great care when seating primers. They are alright, but in operating them the operator should use more brains than brawn. The Schmitt reloading tool has an adjustable stop to limit the travel of the priming punch and, if this stop is properly adjusted for the primers and cases being loaded, it is an effective check against applying too much pressure to the primer. If it is not properly adjusted, all of the primers will be improperly seated. In this connection, it should be born in mind that the primer pockets of different makes and lots of cases are not always of the same depth, even though they are of the same diameter.

Sometimes a reloader finds that when he has his primers seated firmly on the bottoms of the primer pockets, they still project above the heads of the cases. This is almost invariably due to the use of primers that are of a different make than the cases and it is a dangerous condition, as a cartridge with a protruding primer may fire if dropped or by the closing action of the bolt or breech block, if the action is closed violently as in rapid fire or in automatic arms. The illustration on Plate X shows a primer that fired accidently from this cause. Note that the mark of the firing pin *hole* is visible but that there is no mark of the firing pin itself. This is but one reason why it is advisable to use primers of the same make as the cases being reloaded.

Primer Pocket Vents. Another reason for using primers and cases of the same make lies in the sizes of the vents. These vents are of a size suitable for properly igniting the charge with the primer *with which they were loaded*

at the factory. While the primers made by the same manu- 60
facturer and sold for reloading purposes may not be the same as those with which the ammunition was originally loaded, they will be nearer to it than those of another make.

As an extreme example of the importance of vent size to ignition, the heads of two .38 cases are shown on Plate X. One is a Remington case using a *small* primer and having a relatively *small* vent. The other is a Peters case using a *large* primer and having an abnormally *large* vent. We can safely assume that both of these cartridges were equally satisfactory as originally loaded, but it is obvious that the Peters priming mixture used in this instance was less efficient than the Remington mixture and required a larger amount of mixture and a larger vent to obtain proper ignition of the powder charge. The kind of powder used may have had some influence on this however. Now, a large Remington pistol primer will fit that Peters case very nicely, but if we use the Remington primer in it, we will certainly get over ignition of the charge. The vent is too large and the greater quantity of more efficient priming mixture is too much for this cartridge. A maximum load fired with such a combination would certainly be dangerous but then, maximum loads should never be loaded into cases with abnormally large vents, if at all. The large vent will permit a terrific set back of the primer.

If we reverse the order and put a small Peters primer in the Remington case having a small vent, it is obvious that the ignition will be insufficient. The quantity of priming will be too small and the vent isn't large enough, even if the case would take a large size Peters primer. This comparison assumes the use of priming mixtures such as were used in the original loadings. It does not intend to show that one make of primer is better than another, but rather that *any* primer must be used with the proper size of vent to be efficient.

With the older corrosive primers, each manufacturer had his own formulas but these differed only in minor respects
61 and therefore, it was generally permissible to use primers of different makes than the cases they were loaded into, provided they were of the proper type and size. This is not so true of the modern non-corrosive primers. These primers should only be used interchangeably in different makes of cases where the primer pocket sizes and the vents are of the same size.

For the best accuracy and most uniform ignition, the fouling should be removed from primer pockets before new primers are loaded, so that the anvils will rest on solid brass rather than on brittle fouling. You will get pretty good results most of the time if the primer pockets are not cleaned, but the reloader who really wants to produce good ammunition will clean them out. This primer fouling is bulky and can prevent primers from being seated flush with or below the surface of the case heads. Every precaution you can take to insure that your primers are seated solidly and without excessive pressure will be rewarded by improved accuracy and performance of your reloaded ammunition.

Primer Sizes.

All commercial ammunition manufacturers make two different sizes of primers. There is a large size measuring .210 inch in diameter that is adapted for rifle cartridges. This size of primer is also made for the larger calibers of pistol and revolver cartridges but the pistol primers, while the same size, are entirely different from rifle primers. Their cups are softer and thinner, so they will indent easily under the lighter hammer blow of hand guns and they contain pellets of a quantity and kind of mixture suitable to the ignition of fine grained and easily ignited pistol powders. They are not suited for use in rifle ammunition, even though they fit the primer pockets of such cartridges. The cups are too thin and they will not ignite hard grained rifle powders

well. Their use in rifles is likely to result in pierced primers with their attendant danger to the aiming eye, in addition to their unsatisfactory performance.

On the other hand, rifle primers should not be used in pistol or revolver cartridges. They are too hot and strong for 62
igniting pistol powders and may over ignite them, causing high pressures, also the harder or thicker cups offer too much resistance to the blows delivered by the firing pins or hammer noses of hand guns.

The small primer size is .175 inch in diameter. Primers of this size are also made for both rifles and revolvers and the same remarks that apply to the large size primer apply to this size.

The uniformity of primer size in different makes of ammunition makes it possible to use primers of one make in cases of a different make and while there is no harm in using them interchangeably *with reduced loads*, provided they can be seated flush with or slightly below the heads of the cases, it is best to use primers of the same make as the cases, for reasons given above. This is especially true when reloading ammunition with full charges.

Table of Primers.

MAKE	KIND	Large Rifle No.	Diam.	Small Rifle No.	Diam.	Large Pistol No.	Diam.	Small Pistol No.	Diam.
Remington	N C.—N.M.	8½	.210	6½	.175	2½	.210	1½	.175
	N.C.—N.M.	9½	.210						
Peters.....	N C —N M	12	.210	65	.175	20B	210	10	.175
	N C —N M.	20 B	.210	.....		.....		15	.175
Winchester	N C.—N.M.	120	.210	116	.175	111	.210	108	.175
	N C.—N M.	115	.210					108 W	.175
		115½	.210					112	.175
	Chlorate	35	.210						
	N C.—N.M.	225	.225						
Western...	N C.—N.M.	8½	.210	6½	.175	7	210	1½	.175
	Mercuric	8½ G	.210	. . .		.....		1½ B*	.175
Frankford Arsenal.	Chlorate	70 Cal .30	.210	.....		.....		70 Cal .45	.204

United States primers are identical with, and have the same numbers as Winchester primers.

*For black powder only.

Remarks

N.C.—N.M. indicates Non-Corrosive, Non-Mercuric.

The Chlorate primers listed are non-mercuric but not non-corrosive.

The Western Nos. 8½ G and 1½ B primers are mercuric and contain a corrosive mixture. The Western Cartridge Co. does not ship mercuric primers for reloading unless they are specifically ordered by number. In this case the mercuric primers are shipped it being assumed that the purchaser is familiar with their nature. The 8½ G primer is used in the Newton, .300 Magnum and 30 06 Match ammunition and is an excellent igniter but cases fired with it should *not* be reloaded with full charges.

The Winchester No 108 W primer is used in the small pistol and revolver cartridges such as .32 S. & W. and 32 Automatic. No. 112 is used in the 38 auto and .455 Colt. No. 108 takes care of all other cartridges using the small pistol size.

The Peters No. 20 B is used only in the .38 and .44 W.C.F. cartridges. The Peters No. 10 primer is now obsolete as are the Remmington 8½ and Winchester No. 225.

The two sizes of primers just mentioned are suited to all calibers of cartridges with three exceptions. The caliber .45 automatic pistol cartridge *as manufactured by and for the U. S. Government* uses a special size of primer which is manufactured at the Frankford Arsenal. This primer is known as the Cal. 45 number 70 Frankford Arsenal primer. It is .204 inch in diameter and can only be purchased by N. R. A. members, through the office of the Director of Civilian Marksmanship. This size of primer can not be used in any other cartridge than the .45 Automatic. It will not fit *commercial* cases of this caliber, nor Winchester cases manufactured for the Government during the World War. These latter cases take the large size commercial pistol primers. The F. A. number 70 primer is a potassium chlorate primer and is *not* non-corrosive. It is, however, an excellent primer.

For a short time the Winchester Repeating Arms Co., manufactured .30-06 ammunition taking a special large size primer .225 inch in diameter and known as their number 225 primer. This was one of the first non-corrosive primers
63 manufactured and is still obtainable, although now obsolete.

The third and only other exception in primer size is loaded in a lot of Peters Cal. .30-06 ammunition made for the Government. This primer is the same, or about the same size as the F. A. Cal. .45, No. 70 primer. As far as the writer knows, this primer can not be obtained through commercial channels and none of the commercial primers will fit this particular lot of cases.

Note: .32-20, .38-40, and .44-40 cartridges are used in both pistols and revolvers. When reloading them for rifles, use rifle primers but if they are reloaded for revolvers, revolver primers should be used.

64 ***Primers as a Means of Estimating Pressures.***

It is useless to attempt to estimate chamber pressures by the degree of flattening of the primer. The newer non-corrosive primers are so violent in their action that they flatten nearly as much when fired with no powder at all, as when fired with the case full of powder.

Potassium chlorate primers, namely the Frankford Arsenal No. 70 and Winchester No. 35 NF (non-fulminate) will give more or less progressive flattening as the powder charges are increased, but even they are unreliable as a means of estimating with any degree of accuracy what the maximum chamber pressure is. The excessive flattening of any primer should always be heeded as a sign of high pressure, even though this flattening may be due to other causes. Pierced primers are a sign of high pressure, as are primers that leak or permit gas to escape around them.

65

Chapter Three

POWDER.

Gun powder or Black Powder as it is often called, is the oldest propellant known for use in fire arms. As made for small arms, it is usually a mixture of potassium nitrate, sulphur and charcoal. Sodium nitrate is used in place of potassium nitrate in blasting powders which, by the way, should not be used in small arms ammunition as the sodium nitrate makes the powder more violent in its action. It also increases the tendency of the powder to gather dampness and is more difficult to ignite.

Originally, gun powder was in fact a "powder", the ingredients being simply ground up together, but for many years it has been made in a granular form. While none of our propellants are in reality "powders", that name has been attached to propellants for fire arms for so long that it

is inseparably associated with them. The composition of black powder varies only slightly in different countries, the proportions being about 75% potassium nitrate (saltpeter), 10% sulphur, and 15% charcoal. The nitrate and sulphur must be of exceptional purity and only a few woods are suitable for making the charcoal. As a boy, the writer used to make his own black powder of about a 60-20-20 mixture. The saltpeter used was the ordinary commercial product and undoubtedly contained chlorate, perchlorate or even chloride. The sulphur was ordinary drug store, powdered sulphur, which usually contains some sulphuric acid, and the charcoal, by the grace of God, was made from willow 66
because it was found that willow charcoal would pulverize better than some others. The charcoal was correct but it will be seen that about everything else was wrong, including the method of manufacture, which need not be gone into here. At the time, the product seemed to be a great success; it gave a loud report and produced much smoke but the manufacture of *good* black powder is no job for a child and requires much special equipment and above all, experience and skill. In some forms, its manufacture is baffling even to experts.

The process by which black powder is made may be described briefly as follows: The ingredients, of proper purity, are mixed together thoroughly and sifted. They are then "milled" or ground together in special stone or iron 68
mills, with precautions to prevent friction or sparks, which makes a very fine and homogeneous mixture of the powder. It is next pressed into hard cakes or blocks which are dried and broken up to form the granules. These are graded for size by passing them through screens, which permit the largest permissable grains to pass through. The powder is caught on other screens that only permit the dust and grains that are too small to pass through. These grains are glazed by rotating the powder with graphite in closed cylindrical drums, after which the powder is again sifted to remove graphite and dust. The milling operation takes hours and this, as well as practically all other operations, are attended by danger of explosion unless special safety precautions are constantly observed. In fact, black powder is one of the most, if not the most dangerous of explosives to make, handle and store, because of the ease with which it can be ignited; a static spark may set it off and in loading it by machine there is a danger to a degree that does not exist when loading smokeless powders. On the other hand, black powder is the safest for handloading purposes. The proper method of loading it in any cartridge is to use a charge that will fill the case to a point where it will be compressed slightly, or packed by the base of the bullet when the latter 67
is seated to the proper depth. An over charge is practically impossible if the proper size granulation is used.

Black powder, as supplied for reloading purposes, comes in three different granulations. FFFg is the finest and is used only in cartridges of small capacity. FFg is the medium size of granulation and has the widest application of the three. It is used in all medium size cartridges. Fg is the coarsest granulation and is suitable only for use in large caliber rifle cartridges.

It is said that when black powder is fired it gives off about 44% of gaseous and 56% of solid products; herein lies its great fault and lack of efficiency as compared with smokeless powders. The expanding gasses are the only part that causes movement of the bullet and the only way the velocity of a bullet may be increased with black powder is to increase the amount of powder that is burned behind the bullet, so as to produce more gas. The effort to obtain increased range and power in black powder cartridges can be seen from a study of the cartridges in common use about fifty years ago. The cases were continually being made with larger powder capacities to accomplish this result, but black powder, for sporting purposes, has largely gone into the discard in favor of the more efficient smokeless. The writer can remember when powder mills were fairly common establishments around the country and what ramshackle edifices they were. The practice was to build a stout skeleton framework of beams with a good strong roof with a flock of decrepit boards tacked on the sides. I believe the rule was not to use more than one nail to a board and for a very good reason. The workmen mixed the batches or prepared them for other operations and left the building. The machinery was started from outside, by remote control and was allowed to run for the proper length of time, after which it was shut off and the workmen returned. When, as occasionally happened, a "blow" occurred, the explosion followed the path of the least resistance and blew the building as clean of boards as a plucked chicken is cleaned of feathers. It was rare indeed for anyone to get hurt and all the boys had to do was gather up the boards, tack them in place, clean up the machinery and business went on as usual.

But to get back to the powder itself. Black powder gives a rather heavy recoil as compared with smokeless. This is due to the large amount of solids produced when the powder is burned; about 56% of the weight of the charge, which, from the standpoint of recoil, is just like adding that much weight to the bullet.

Recoil is divided into two parts; the primary recoil which is due to the velocity and weight of everything that goes out of the muzzle of the gun as opposed to the weight of the gun itself. The products of combustion and the bullet that leave the barrel are known as the ejecta and include the weight of not only the bullet and solids of combustion but the weight of the gasses as well. If the ejecta were equal in weight to the weight of the gun, the gun and the ejecta would leave each other at equal velocities when the gun was fired but, of course, guns are much the heavier of the two and consequently recoil at a very much lower velocity. The secondary recoil is due to the expansion of the gasses against the atmosphere, it also pushes the gun to the rear.

When smokeless powders are fired, they also decompose into gasses and solids, but the solids represent only a small percentage of the total and they develop a much larger volume of gas than an equal quantity of black powder. This means that they can give bullets a higher velocity than is possible with black powder and that they are relatively free from fouling and smoke. This means that the weight of the ejecta is less, which makes for a reduction in recoil, but the velocity of the ejecta is increased which partially offsets this.

Smokeless powders are more difficult to ignite than black powder and when first introduced, the black powder primers

then in use would not ignite it properly. It was common practice to place a small priming charge of black powder in the base of a cartridge before loading the smokeless 69
powder charge, in order to get good ignition. The primer would ignite the black powder which, in turn, would produce an adequate amount of flame and heat to ignite the smokeless. This practice should *not* be followed in loading ammunition today, unless the circumstances are exceptional. With full charges of smokeless powders and modern primers, the addition of a black powder priming charge will increase the rate of burning of the charge over the expected point and can easily cause dangerous pressures. These priming charges may be used with reduced or low pressure loads but will rarely contribute anything to the performance of the ammunition.

Series of spark photographs made by the late Capt. Philip Quayle for Col. R. M. Cutts and published with the permission of the latter. These show how gas escapes between the expanded neck of the cartridge case and the bullet, before the latter starts forward. If the necks did not let go of those bullets first, how did that gas get out ahead of them?

PLATE VII.

Regarding the use of black powder in bottle neck cartridges, it can be used and if the barrel is kept clean, very good accuracy can be obtained with it. The objection to its use in these cartridges lies in the inability to compress the charge well, as the bases of bullets are smaller in area than the cross section of the powder charge. This will increase the fouling slightly but the principal difficulty relates to the large volume of powder in relation to the small bore. Remember that over half of the weight of the charge turns into fouling and smoke. A bottle neck cartridge of small caliber chokes the free passage of the products of combustion and not as much of it blows out of the muzzle of the gun as from a cartridge having a straight case, the inside diameter of which is approximately equal to the diameter of the bullet. A heavy deposit of fouling will quickly pack into the grooves of the barrel and render the arm inaccurate until it is cleaned out. For removing black powder fouling there is nothing better than water, and some very nice shooting can be done if the bore of the arm is wiped out with a wet patch after every few shots.

Semi-Smokeless Powder

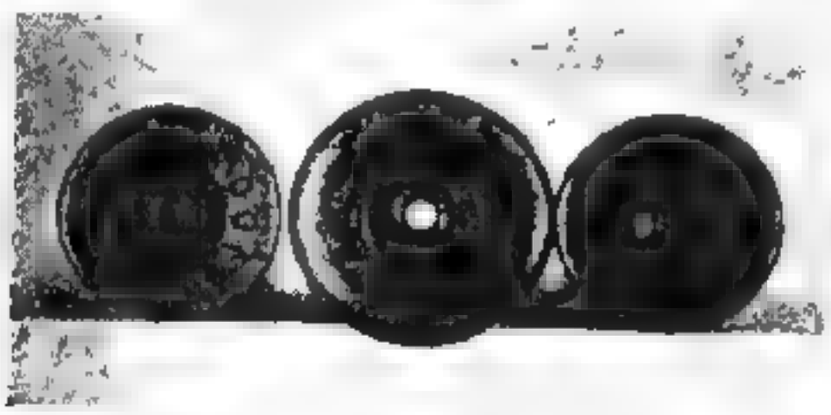
Semi-smokeless powder is a mixture of black and smokeless powders, the two being incorporated during the process of manufacture. One doesn't hear much about it, but it is
70 probably the best of all powders for a reloader to begin on and it is unfortunate that the manufacturer does not advertise it more widely. It is made in a variety of different granulations and can be used in all cartridges whether straight, tapered, or bottle-neck and in all calibers of rifles, revolvers and even shotguns. It does not leave the heavy fouling of black powder and while not as clean burning as smokeless, one can, nevertheless, fire long series of shots with it without fouling the barrel enough to affect accuracy. It may be measured with perfect safety with dip measures and is usually loaded in the same volume as black powder, although it is not advisable to compress the charges as with black powder.

Semi-smokeless charges, while of about the same volume as black powder charges, are much lighter in weight, as black powder has much the higher specific gravity of the two. The only possible danger in loading semi-smokeless lies in over-compressing charges or using a finer granulation than that recommended for the cartridge being loaded. If you can not get the granulation you want or have some on hand that you wish to use up that is not of the proper granulation for the cartridge being loaded, use a coarser granulation rather than a finer one. If a finer granulation is used, the charge should be cut down about ten percent. This is a good safe rule to follow, even though it is not necessary to do so with all cartridges.

Semi-smokeless powder is manufactured by the King Powder Co., Kings Mills, Ohio. It is moderately priced and can be shipped by express anywhere in the United States. The manufacturer can supply leaflets with tables of charges showing the correct granulation for all calibers of cartridges. Because of the simple method of loading and the nature of the powder, semi-smokeless is useful in loading odd calibers of European cartridges for which no smokeless powder loading data is available in this country. To select the proper granulation for such a purpose, compare the foreign cartridge with the nearest American cartridge to it in caliber
71 and capacity, then get the powder recommended for the American cartridge. If your cartridge is a little larger in

caliber or holds more powder than the American cartridge nearest to it, use the next larger granulation of semi-smokeless powder. For making comparisons, an ammunition catalogue will do as the illustrations in these catalogues are usually made the actual size of the cartridges.

Berdan Primer Pockets.
The case on the left is an old Sharp's folded head case. The one on the right shows the conventional form of anvil and is of recent manufacture.



Berdan primer pockets with central flash hole through the anvils to permit pushing fired primers out. The center case is an old .40-90 Ballard case, probably over 60 years old. The cases flanking it are of recent manufacture.

PLATE VIII

Lesmok Powder.

It is unlikely that anyone who reloads ammunition will ever run into any of this powder but if the reader should by chance come into possession of any of it, get rid of it quick. By getting rid of it I mean dump it on the ground and burn it, or throw it in the creek. This powder is used today in loading .22 caliber, rim-fire ammunition and it is probably the most dangerous powder to load that there is. Lesmok powder acts like semi-smokeless with respect to the fouling that it leaves in the bore of a firearm but that is as far as the similarity goes for Lesmok is a mixture of black powder and GUN COTTON. It ignites easily and can be fired by friction or by a blow. Even in the hands of those thoroughly familiar with it in the ammunition plants, flare-ups occur with it and it is only because of special precautions and safeguards that these are not serious.

Smokeless Powder

This is the type of powder that is most widely used for handloading ammunition as well as in ammunition manufacture. Any reloader who can follow simple directions and who is willing to stick to the more moderate charges of powder can use smokeless powders with safety and entire satisfaction, but when using full charges or departing from recommended loads in any detail, one's knowledge of powder can not be too complete.

Smokeless powders, unlike black powder, are chemical compounds rather than mechanical mixtures. No two powders are alike and as the chemical reactions and combinations that take place during the manufacturing process can not be controlled exactly, there is often a considerable
72 difference in the performance of two batches or lots of the same powder. The power of powder is dependant upon the amount of nitrogen that it contains. In black powder, the nitrogen is contained in the potassium or sodium nitrate that forms a part of it. As these substances can be accurately measured and as their nitrogen content is definitely fixed, it is possible to get the same amount of nitrogen into each batch of powder. This is not true of the manufacture of smokeless powder, the body of which is nitrocellulose. Nitrocellulose, as used in American powders, is cotton waste or linters nitrated by treating with nitric and other acids. After nitration, the acid is washed out by boiling in changes of water for several hours. The water is removed from the nitrated cotton first by centrifical wringing, then the remainder by forcing alcohol through the wet cotton, the alcohol displacing the water.

The nitrocotton is then reduced to a plastic gelatin-like condition by the use of suitable solvents in mixing machines during which process the stabilizing agents, salts, or deterrents are incorporated. Much of the solvent used is recovered and used over again.

The amount of nitrogen taken up by the cotton depends upon the strength of the acids used, as well as the length of time the cotton is exposed to the nitration treatment. Some of the nitrogen taken up by the cotton is lost in the later washing and boiling purification process. Large blends of the nitrated cotton are made so that the average nitrogen content is virtually the same from lot to lot.

The gelatinized nitrocellulose is squeezed through dies and formed into strings of a size suitable for the ultimate purpose the powder is to serve, either as a solid string or with a small hole through the center, after which it is cut into grains of the proper length and dried.

Smokeless powders are divided into two classes; nitrocellulose or single base powders which are of nitrocellulose with a stabilizer salts, deterrent, etc., and nitroglycerine or double base powders which are made from nitrocellu-
73 lose also but with nitroglycerine added, with or without a stabilizer or deterrent. A stabilizer is an agent used to arrest any chemical action in the powder so that it will not deteriorate rapidly in storage; diphenylamine or crude vaseline being used extensively for this purpose.

There has been much argument over the relative merits of nitrocellulose and nitroglycerine powders, it being claimed that the latter are much more erosive than the former. This is probably true with powders containing a large percentage of nitroglycerine because of the high burning temperatures developed, but if the quantity of nitroglycerine is not large, there is little difference in the erosion caused by the two types of powder. When used in reduced loads, neither of these powders are erosive. In making nitrocellulose powders, it is impossible by any practicable means to recover or drive off all the solvents and anyone opening a fresh canister of nitrocellulose powder will readily detect the strong odor of ether. The remaining volatiles, or solvent in the powder, will gradually evaporate and will do so more rapidly if the

powder be stored in a warm place. This changes the ballistic properties as the solvents act as a deterrent and their loss consequently somewhat speeds up the burning rate of the powder and higher pressures will result. The reader should not be alarmed at this statement as our nitrocellulose powders will stand long storage under proper conditions.

Nitroglycerine powders, on the other hand, use a smaller amount of acetone solvent becaues of the solvent power of the nitroglycerine, and hence the grains are not apt to change due to solvent loss, no matter how long the powder is stored. Nitroglycerine powders are the easier of the two to ignite, they burn a little more uniformly, and because of their higher nitrogen content are more powerful, which means that they can be used in smaller charges than nitrocellulose powders to develop the same ballistics. Because of their ease of ignition, nitroglycerine powders are not so susceptible to primer faults as other powders. The reader

may suspect that I am prejudiced in favor of nitroglycerine 74
powders. I am and because I have always been able to get just a wee bit better results with them. It should be borne in mind, however, that one person's opinion doesn't prove a thing, nevertheless, it is perhaps significant that some of the new line of duPont powders contain nitroglycerine. And this after the long years that the duPont boys have preached about the horrors of nitroglycerine in powders, years, by the way, during which the duPont Co. made nothing but nitrocellulose powders. Well, they are nice boys just the same and the new powders are excellent.

For many years much has been made of the erosive properties of nitroglycerin powders. It is true that nitroglycerine powder is more erosive than nitrocellulose powders but only when the nitroglycerine content is high. This is largely due to misunderstanding, and the fact that the corrosive effect of the older type primers was generally attributed to the erosive properties of the powder instead of to the primers where the fault actually lay.

Glycerin is just one of many substances that will take up nitrogen when treated with nitric acid. When nitro-glycerin is added to nitro-cellulose it simply increases the potentiality or nitrogen content of the resultant powder. If two charges of powder of equal volume, one containing nitroglycerin and the other being of straight nitro-cellulose, are fired in the same chamber under the same conditions, the powder with the higher potential will develop the greatest amount of heat. As heat is closely related to the subject of erosion, the powder of the higher potential will be the most erosive. This forms the basis of the statement that nitro-glycerin powders are more erosive than nitro-cellulose powders, but the hitch comes in that the two kinds of powder are not loaded in equal volume. Because of the higher potential of double base powders, smaller charges of them are required than single base powder to impart a given velocity to a bullet, and the pressures developed by the double base powders are frequently less than those that

must be developed by a straight nitro-cellulose powder to 75
obtain the same velocity. As the heat, or burning temperature produced, is influenced by the chamber pressure a double base powder will sometimes develop less heat and consequently be less erosive than a straight nitro-cellulose powder. The mere fact that a powder has nitro-glycerin in it means nothing in itself as far as erosion is concerned. The whole matter is one of potential or nitrogen content and it is possible to produce a nitroglycerin powder of lower potential than a straight nitrocellulose powder.

The DuPont Company has for many years been identified with the manufacture of straight nitro-cellulose powders. Their new line of I.M.R. Powders are of this class and are excellent. Their new Pistol Powder No. 6, however, contains a small percentage of nitro-glycerin and this powder, because of its easier ignition and more uniform burning, is a considerable improvement over the now obsolete single base Pistol Powder No. 5.

The manufacture of nitroglycerine powder differs from the manufacture of nitrocellulose chiefly in the addition of the nitroglycerine. The proper amount is added to the dry nitro cotton, which is afterward worked thoroughly in a mixing machine. The mineral jelly or stabilizer is added while the batch is being mixed with the solvent, as with straight nitrocellulose powder. The general manufacturing process is the same for both and as this book pertains to the reloading of ammunition rather than to the manufacture of powder, the details of the process of making powders is purposely omitted.

Rate of Burning. Uniform ballistics or uniformity from one shot to another, can only be obtained by a uniform rate of burning of the powder. The rate of burning of any powder is therefore of the utmost importance in obtaining good accuracy and as the burning rate, especially of smokeless powders, is not fixed entirely by the composition of the powder itself, it is important that the handloader understands something of this.

76 If some black powder is ignited in the open air, it will burn with a quick flash, while smokeless powder burned in the open is consumed slowly. The rates of burning of these two classes of powder, when burned in the open, are obvious. When smokeless powder is loaded into a small arms cartridge and fired in the usual way, it burns quickly, therefore the rate of burning of smokeless depends upon the degree of confinement under which it is burned and this degree of confinement varies with the caliber and shape of the cartridge case and the amount of powder used, as well as a number of other things. In order to get this matter of rate of burning more firmly fixed in our minds, let us consider another simple example.

If a dry piece of string a foot long be ignited at one end, it will burn slowly until entirely consumed. Now, if we take a strip of pure nitrocellulose the same length as the string and ignite one end of it, it will be found to burn more rapidly than the string but, like the string, it will burn progressively from one end to the other. If a one foot strip of nitrocellulose having nitroglycerine incorporated in it is burned, it will be consumed more rapidly than either the string or the pure nitrocellulose. In short, the three substances have different rates of burning. The rate of burning is merely the speed with which any substance is consumed by burning and is usually measured in feet or

meters per second. It is governed by the amount of oxidizing agents present or, in other words, the amount of the substance that turns into oxygen when decomposed. It so happens that nitroglycerine is the only organic explosive that contains more oxygen than is necessary to burn it completely when excluded from the air and its incorporation in powder helps the combustion and increases the rate of burning, therefore, nitroglycerine powders burn more rapidly than nitrocellulose powders, all other things being equal. There are ways of controlling the rate of burning of powders other than by their chemical composition, as we will see presently.

Getting back to our strips of powder, if twelve one inch 77
pieces of powder are all ignited at the same instant, they will be consumed in one twelfth the time required to burn a single strip one foot long. Twenty-four one-half inch pieces will burn in one-half the time required to burn the one inch pieces, etc. Therefore, the burning time is also affected by the size of the pieces of powder and the area that is ignited. The rate of burning is also affected by, not only the size of the pieces or grains of powder, but by their shape as well.

When a cartridge is fired the powder charge "explodes," the explosion being nothing more than rapid combustion or burning of the powder. In burning, the outer surfaces of the grains are consumed first, the grain decreasing in size as successive layers are consumed until the grains are entirely consumed. No matter how fast the powder burns, it always burns towards the center of the mass. Combustion is the oxidation of a substance and burning is rapid oxidation and is accompanied by the production of heat, and the rate of burning influences the heat or temperature produced. By way of example, we can consider a piece of wood. If exposed to the elements for a period of time it will decompose or rot. If ignited, it will decompose by burning, but the decomposition will be rapid and accompanied by the production of heat. The decomposition is, in both cases, due to oxidation and, believe it or not, the heat produced in both cases is the same. In the process of decay, the heat is given off so slowly and is so quickly dissipated that there is no measurable rise in temperature, as when burning takes place, and likewise, in both cases the decomposition starts on the outer surface and works toward the center of the

Up until 1860 gunpowder was used in solid granular form, or for artillery was pressed into solid blocks or cakes of various sizes and shapes. Powder of any kind burns from the exposed surface toward the center of the mass and the work that it can do depends upon the amount of gas given off. The area of a solid grain of powder is reduced and the grain becomes smaller and smaller until it is entirely con- 78
sumed, consequently it will give off the greatest volume of gas at the instant that the entire surface is completely ignited. When burned in a closed chamber, the expanding gasses build up pressure that in turn forces the bullet or projectile forward. One of the laws of moving bodies having weight is that they can not be set in motion except at the expense of time and even after the chamber pressure is above that required to overcome the weight and inertia of the bullet and impress it into the rifling of the barrel, a certain amount of time is required to accomplish this. After the bullet once commences to move, the space in which the gasses are expanding continually and rapidly increases, as the bullet moves along the bore. This additional space relieves the chamber pressure and it is desirable to have the gasses reach their maximum pressure after the bullet is in motion. The ideal condition would be to have the pressure rise gradually until the bullet starts to move and to continue to rise, accelerating the bullet all the way to the muzzle of the arm. This would develop tremendously high velocities but it is impossible of accomplishment. On the contrary, the thing that must be avoided is having the pressures rise so rapidly that they exceed safe limits before the bullet has time to move, or to move far enough to leave enough space behind it for the gasses to expand in with safety.

Black powder is porous and if burned at too high pressure, the gasses will be driven through the grains causing almost instantaneous ignition and dangerous pressure. Smokeless powders, because of their close grained and horn like nature will stand higher pressures than black powder, but there are limits to the pressures that even they will stand.

As solid grains of powder evolve the most gas at the instant their entire outer surface is aflame, it stands to reason that in a closed chamber they develop the maximum pressure at this point. Powder charges do not ignite throughout at once. The primer ignites the rear of the charge, more or less of which burns, causing the development of heat and
79 pressure which ignite the remainder of the charge and accelerate the burning. We have seen by comparison that the pressure under which powder burns affects its rate of burning by comparison with powder burned at atmospheric pressure and when fired in a gun; the higher the pressure, the faster the burning. Consequently, the rate of burning and the rise in chamber pressure is a progressive and accelerated phenomenon, each promoting the other. With solid grained powders the maximum pressure is reached quickly and the rapidly decreasing burning area of the charge causes it to fall off rapidly.

In the year 1860, Col. T. J. Rodman conceived the idea of making artillery powder in the form of large washers that would just fit the chambers of the guns it was to be fired in. His theory was, that if the inside of the washers were ignited, the burning area of the charge would *increase* and there would be a constantly *increasing* volume of gas to accelerate the projectile which would increase the muzzle velocity; and practice bore out the theory. The form of the pressed powder soon changed but the principle was maintained and this was the forerunner of our present perforated powders. These powders burn both from the inside and the outside at the same time and as the outside area decreases, the inside area increases. Once a charge of tubular grained powder is fully ignited, the rate of burning is much more even than with solid grained powder but the grains burn from the ends and constantly decrease in length and it, like any other powder, is subject to the influence of the increased burning space due to the movement of the bullet. That tubular powder does burn from the inside as well as the outside is easily proven with a piece a couple of inches or more in length, such as Cordite, used by the British Army. Light one end of it and, by blowing hard, the fire on the outside can be blown out but the inside will

continue to burn. Another example of this can be found in artillery powder which has a number of holes through it. When such powder is fired, the area of all the holes increases until they meet and the little triangular pieces that are left are blown out of the gun. They can usually be found on the ground out in front of the gun and are known as "powder slivers."

By using perforated powder grains it was possible to get higher muzzle velocities than formerly because the more uniform burning gave a more sustained pressure and greater acceleration to the bullet, but the maximum pressure was still reached after the bullet had moved only a very short distance along the bore. Ballisticians were (and still are) working to delay the initial rate of burning of the powder until the bullet has moved further forward before "giving it the gun" in the form of accelerated burning of the charge and a greater gas volume. The increased space provided by the movement of the bullet would permit this to be done without causing dangerous pressure, but the trick was to do it. A considerable amount of progress has been made along this line since the World War. Some powders are now coated or impregnated on the surface with substances that slow up their initial rate of burning. These powders are a little harder to ignite than plain burning powders but the surface of the grains burns slowly, relatively speaking, and builds up the chamber pressure more slowly, giving the bullet more *time* to move forward and allowing it to move farther forward before the flame reaches the unimpregnated and fast burning part of the grains. The greatest liberation of gas occurs after the bullet is in motion and while the position of the bullet at the time the highest pressure is reached, has only been advanced a fraction of an inch by the use of coated powders, even this small amount has resulted in a great increase in muzzle velocities.

It is unfortunate that the factors influencing the rate of burning of powder, and especially of smokeless powder, can not be explained in a few words but the phenomena are so involved and inter-related that it is difficult to explain some of them at all. The factors thus far discussed that affect the rate of burning may be summed up as follows:

1. The chemical nature of the powder itself. 81
2. The physical nature of the powder. (Hardness or porosity).
3. The degree of confinement under which it is burned.
4. The pressure under which it burns. (Related to confinement and temperature of burning).
5. The temperature of burning. (Related to confinement and pressure).
6. The size of the powder grains.
7. The shape of the powder grains.
8. The strength and heat of the primer.

Practically all of these factors represent things over which the handloader has no control whatever and the discussion of them therefore becomes purely academic. But there is one of them that can be and must be observed and controlled when reloading ammunition. I refer to the confinement of the charge.

Density of Loading. The relation of the volume of the powder charge to the volume of the chamber it is fired in is called the density of loading and the more nearly equal the two become, the higher the density of loading is said to be. The two things that increase the density of loading or confinement of the charge when reloading ammunition are: an increase in the quantity of powder used, and increasing the depth of seating of the bullet. The increased confinement alone from either of these causes will cause greater pressure to be developed in the chamber, to say nothing of that caused by the additional gas liberated by the heavier charge of powder. When loading full charges of powder in any cartridge, any increase in the seating depth of the bullet over the recommended depth of seating should be accompanied by a corresponding decrease in the volume of the powder charge. With reduced charges, the depth of seating of the bullet is not important from a safety standpoint, provided the reduction in the charge is sufficient to off-set the additional space occupied by the bullet.

82a These two factors are not exactly in direct proportion, as any decrease in the charge is accompanied by a reduction in the total amount of gas given off, but a handloader will never get into trouble by considering them as directly proportional.

Some cartridges have a low density of loading normally. The revolver cartridges, most of which were designed to use a large bulk of black powder, are examples of these. Loaded with smokeless powder, the charge occupies only a small part of the cartridge and with any normal charges and bullets, the depth of seating of the bullet is not critical and can be increased slightly if necessary. When, however, deep seated wad-cutter bullets are used, the confinement of the charge becomes too great and must be compensated for by a hollow in the base of the bullet, a reduction in the powder charge, or both.

Two other factors that affect the rate of burning and which may be listed in continuation of those previously mentioned are:

9. The volume of the powder chamber in relation to the sectional area of the bullet.
10. The shape of the powder chamber.

The sectional area of the bullet is directly related to the caliber. Because of the differences in volume and shape of different cartridges, the powder charges recommended for one will not give the same ballistics in another cartridge even though the other cartridge is of the same caliber. Likewise, if two cartridges had the same powder capacity and used the same bullets, charges would not be interchangeable in them because of differences in the shapes of the chambers for them. I know of no two cartridges in which this condition exists, outside of a few experimental ones and the comparison is offered only as a hypothetical one. Even a change in the angle of the shoulder of a bottle-neck cartridge is sufficient to cause a considerable difference in the way the powder charge burns. By change in angle of the shoulder, I mean a deliberate and appreciable reform-

83 ing of the shoulder and not any slight change that may take place when the case expands to the limits of a normal chamber.

Tolerance and Balance Point. If all powders burned exactly alike and burned uniformly regardless of chamber

volume, caliber, bullet weight, etc., we would only need one powder for loading all calibers of cartridges. But they don't. Each powder has its own peculiarities and limitations of use, for reasons already explained and each one has a point in its pressure curve at which it burns best. This point is called the balance point.

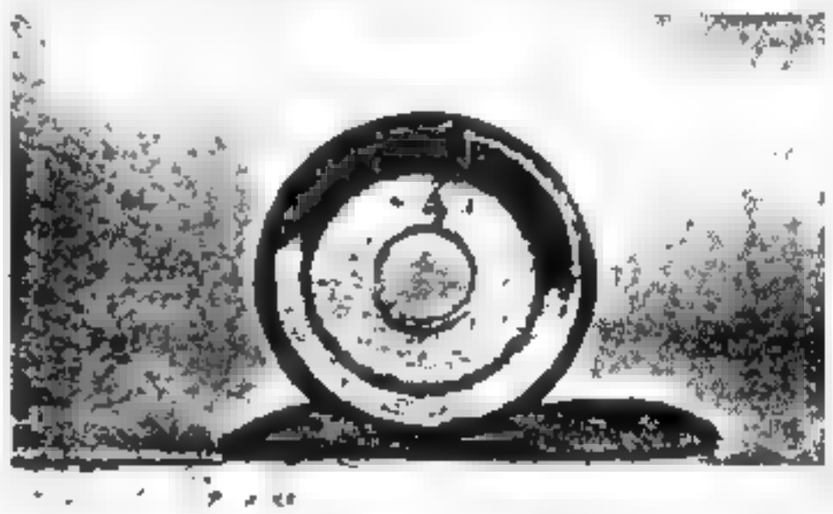
When, for example, the bolt of a rifle is being designed, its outside diameter is fixed at a dimension that will permit it to work freely back and forth in its receiver. As it is very expensive to make mechanical parts to exact dimensions, some allowance must be made for slight variations that are bound to occur in commercial production, due to wear of the tools, etc. It is necessary, therefore, to establish the maximum diameter of the bolt at a point where it will not stick or fail to operate and the minimum diameter so it will not be a loose and sloppy fit. This gives the workman a little latitude to work in and still produce a satisfactory bolt. The permissible variations above and below the standard, or ideal, dimension are known as the tolerance. It is just so with smokeless powders and each one of them has a limit of pressure above and below the balance point, within which they will burn efficiently and uniformly and this range of pressures is also called the tolerance.

If a powder is burned at a pressure below the lower limit of its tolerance, it may fail to burn uniformly and this will cause variations in velocity and poor accuracy. Even though the burning is fairly uniform, it may not be complete and part of the powder may break down into products that are injurious to the barrel. If the nitrates are not consumed, they can gather atmospheric moisture and form minute quantities of nitric acid which will cause rapid rusting, regardless of any magic non-corrosive primers. It is bad business to burn powders at pressures below the lower limits 84
of their tolerances, but it is not unsafe.

As pressures approach the upper end of the tolerance, the pressures are still safe, even though they may be high, but they are approaching a pressure level at which they will burn erratically. The upper limit of the tolerance does not represent a point which, if exceeded slightly, will cause bursting pressures. It does represent a point beyond which the pressure developed can not be predicted with any degree of certainty. When this point is exceeded and whether the excess pressure is due to too much powder, too hot a primer, too large or hard bullet, or a bullet that is too heavy or too deeply seated for the charge, the pressure and velocity will become erratic. Loads developing pressures toward the upper limit of the tolerances are known as "maximum *permissible* loads". They are not to be confused with *maximum* loads, about which more and very bad things will be said later. Erratic pressures are jumpy, uncertain pressures. A person may exceed the maximum permissible load for a certain powder and cartridge and apparently get away with it, shooting his ammunition in blissful ignorance of the way the pressures are jumping around. Then, for no apparent reason, one goes sailing up to the sky and he finds himself with his rifle in two pieces, one in each hand. Or maybe somebody else finds him. "Why! I can't understand it! I have been using that load for two years and am *very* careful about loading it—weigh the powder and bullets 'n everything!" Have you ever heard it? Of course he can't understand it. If he knew enough about powder to understand it, he wouldn't have used the load in the first place.

The tolerance of a powder, unlike that of the rifle bolt referred to previously, must be determined *after* the powder is made. When a new lot of powder is made, a charge, pressure and velocity curve is established to determine its ballistic properties. Assuming that the new powder is an attempt to duplicate a previous lot, the ballistic records of the previous lot are referred to as a guide to the selection of
85 a charge to start with. From three to five cartridges, depending upon the caliber of the cartridge, the practice of the laboratory, or expediency, are loaded with a very moderate charge and are fired for pressure and velocity. The mean or average of the pressure and velocity readings for this series of shots are plotted as two points on cross section paper. These results are compared with the firing data of the previous lot for similarity, or lack of it, and another somewhat higher charge is determined upon for the next series of shots, the mean results of which are plotted as a second pair of points.

.38 Special cases with folded heads which have had the webs cracked and blown away. This is a serious fault in fired cases and should be watched for. It permits an excessive pressure to reach the primer, driving it back violently against the recoil plate of the revolver and may damage the latter.



A revolver recoil plate which has been cracked by the primer set-back from high-pressure loads or cases having enlarged flash-holes.

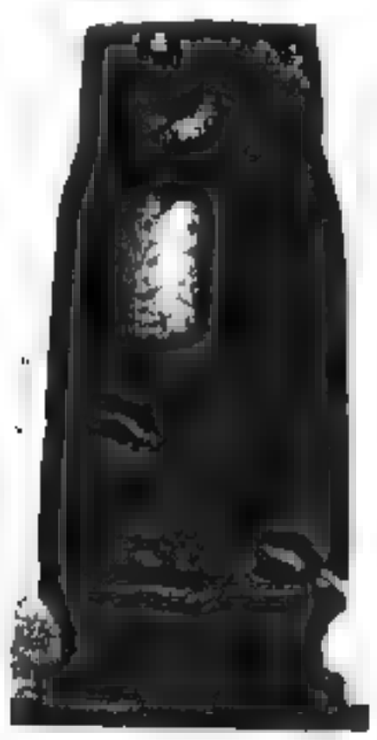
PLATE IX.

This process of gradually increasing the charges, loading and firing a series of shots and plotting the pressure and velocities obtained, continues until the maximum permissible pressure for the cartridge is reached, or the pressures become erratic. Rifles can be mounted as pressure gages for routine tests but for experimental work with powders of unknown characteristics, special heavy guns are used that will withstand tremendous pressures.

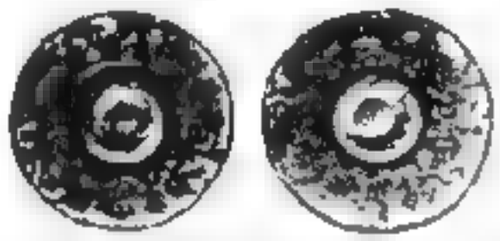
The result of this firing leaves a sheet of cross section paper with two series of dots on it; one representing pressures in relation to the weights of charges and the other representing velocities, also in relation to the weights of charges. Velocities can be taken quite accurately and the

velocity points will represent quite an orderly progression. The ordinary method of taking pressures is somewhat crude, though satisfactory, and points representing pressures, when connected by straight lines, bear more resemblance to a portrayal of lightning or an Indian tepee than they do to a curve, so these "curves" must be smoothed out. This is done by drawing a regularly curved line that will, without breaking its regularity, pass through as many of the dots as possible. (See frontispiece.)

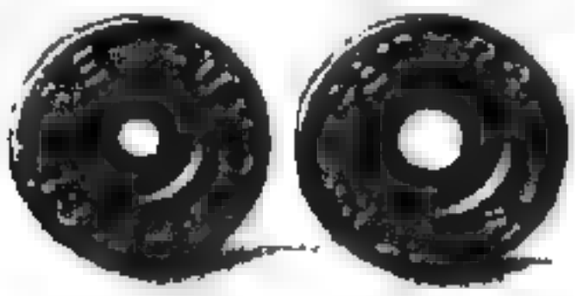
If the loads first fired were below the tolerance of the powder, the dots or points representing the "curves" will vary up and down. If the firing is carried beyond the upper limit of the tolerance, the points will vary up and down,



An automatic pistol case which has been fired to destruction with mercuric primer. Originally fired with a mercuric primer, it was then reloaded and fired three times with non-mercuric primers—with the result shown above.



These cartridges fired prematurely from the slam of the breech block because the primers projected slightly above the case heads. Note the mark of the firing pin hole and the absence of firing pin indentation.



An extreme example in variations in vent sizes as described on page 60.

PLATE X.

but their general course will represent a decided flattening 86
of the pressure curve all out of proportion to the flattening of the velocity curve. The higher pressures go, the smaller the increase in velocity for each increase in the charge. In the pressure curve there will be a range where the plotted points will coincide quite well with the smoothed out curve. This uniform range represents the tolerance of the powder and the point of the greatest uniformity is the balance point. The tolerance may be wide for one powder and narrow for another, but that is the way the job is done. In making up tables of charges, the powder companies must establish curves, not only for each powder but for every cartridge that those powders are used in and for each different bullet as well. It can be seen that there is an immense amount of work, to say nothing of expense, in back of every one of these tables. We handloaders are indeed fortunate in having such authentic and complete data available for the asking.

In the acceptance tests of military powders, the charge, pressure and velocity curve must show that the powder being tested will develop the proper velocity in the cartridge and with the projectile specified, without exceeding the permissible pressure. The velocity that the projectile must have and the maximum permissible pressure for the guns the powder is to be fired in, are fixed in the specifications and the powder must meet those specifications or it will be rejected. This is necessary because the military requirements of the ammunition are such as to necessitate a uniform muzzle velocity from one lot of ammunition to another.

This need for rigid powder specifications does not exist in commercial sporting ammunition except in a few special instances. Consider our own military requirements for powders for small arms ammunition; we have only three calibers, .30, .45 and .50 and we could get along with only three different powders if we had to. Now in comparison, just take a look at the variety of cartridges, different weights of bullets with which they are loaded, etc., in any ammunition catalogue. Each one of those cartridges presents its own
87 loading problems and the range is so great that the commercial manufacturer *needs* a variety of powders of widely different burning characteristics. Even though a new lot of powder may not burn properly in the range of cartridges it was manufactured for, its burning characteristics may be exceptionally good when fired in a different range of cartridges than that for which it was intended. For example, a powder made for the .30-06 cartridge may, on test, be found to develop too high pressures, which indicates that it burns too quickly for the .30-06 and that when tested in the Cal. .250-3000 cartridge it gives high velocities with perfectly safe pressures. The commercial manufacturer has all the necessary laboratory equipment for determining the suitability of powders for his loading requirements and can use lots of powders that are "off" from the standard, very nicely. For this reason there is no certainty as to the kind of powder that is used in different lots of any caliber of commercial cartridge and commercial ammunition is subject to wider variations in velocity from one lot to another than military ammunition. The manufacturer endeavors to load as closely as possible to the advertised velocity but the primary objects sought are satisfactory performance and safety.

The Measurement of Pressures.

Here in the United States pressures are customarily measured by what is known as the radial system. A heavy steel yoke is mounted around and over the chamber of the barrel in which the pressures are to be taken. A hole is drilled through the base of the yoke that encircles the barrel,

into the chamber. A steel piston is closely fitted to the hole, with just enough clearance so it may move up and down freely. A heavy thumb screw passes down through the top of the yoke and a steel block, called the "anvil", is made to fit loosely inside of the yoke. The fit of the anvil is such that it can be readily removed and replaced and its upper and lower surfaces are ground smooth and parallel. This constitutes the mechanical part of the gage. Pressure gages for rifle cartridges usually have the piston located one inch from 88
the head of the cartridge but for revolver and pistol cartridges the pistons are located just ahead of the front edge of the cartridge case.

A small copper cylinder called a "crusher" is used to measure the pressures developed within the chamber. These crushers must be of uniform hardness, or more properly, softness, as it is upon their uniformity of viscosity that the uniformity and accuracy of the readings depend. The method of using a crusher gage is as follows. A cartridge is placed in the chamber and a gas check cup, similar to a gas check used on a cast bullet or a primer without an anvil, is filled with grease and inserted in the piston hole, base up. The piston is inserted on top of this and pressed down until the edge of the gas check is in contact with the cartridge. The gas check and grease serve to prevent the escape of gas past the piston. A crusher is placed on it, first having been carefully cut to length and measured with a micrometer caliper, end on top of the piston and the anvil on top of the crusher. The thumb screw is turned down so as to bear firmly on the anvil, but not with a pressure that will disturb the dimensions of the crusher. This thumb screw, through the anvil, supports the thrust of the crusher when the gun is fired. When the cartridge is fired, the internal pressure, acting radially against the chamber walls, also acts upon the piston of the gage, forcing it upward and compressing the crusher. The crusher is then removed and measured again to determine the reduction in its length and the amount of reduction is used as a measure of the maximum pressure developed in the chamber. The pressure is expressed in terms of pounds per square inch, but actually it is nothing of the kind. This method is crude and has many faults but it is convenient and affords sufficient accuracy to insure the loading of safe ammunition. The figures obtained vary considerably, for many reasons that need not be explained here and are subject to interpretation by those whose experience makes them competent to do so. The
average person is apt to consider the numerical values of 89
pressures, expressed in terms of pounds per square inch in powder charge tables, as fixed values of measurement in the sense that a one pound weight or a foot rule are fixed values. This is a mistake and other than to indicate a maximum point beyond which charges should not be used, they are of no particular value in tables of charges.

One thing a crusher gage does not show is the *time* required for the pressure to reach its maximum point. If the pressure is close to the bursting point of a gun, this element of time is of great importance for if the maximum point is reached too quickly, the molecules of the steel will not have time to adjust themselves to the strain and the gun will burst. As an example of the effect of the element of time on applied force, a simple experiment can be made with a piece of ordinary tar. At room temperature the tar is quite hard, but it may be slowly bent or deformed with the hands. All that is necessary is to apply the force slowly enough so that the molecules can adjust themselves to it. But if we strike the tar a sharp quick blow it will break, because the force is applied so quickly that there is insufficient time for the molecules to readjust themselves, although the energy of the blow may be even less than that previously applied with the hands. It doesn't pay to experiment blindly with powder charges when the pressures are around the upper limits of the tolerance, nor is it necessary to do so. Both the duPont and Hercules powder companies are willing to assist reloaders who desire to experiment with unknown loads and will make pressure determinations for them at a very reasonable charge; about one dollar per shot, if I remember correctly. This may seem like a lot of money, but the reader should bear in mind that it costs around two hundred dollars to make a pressure gage and the life of one of these gages is only from about two hundred or less shots up to five hundred at the most. From this it will be seen that the charge made hardly more than pays for the wear and tear on the gage.

90

The Measurement of Velocities.

The speedometer of an automobile, as its name indicates, registers the speed in miles or kilometers per hour that the car is traveling at, at any particular time. If we wish to determine the average speed of the car between any two points, a speedometer is useless and we must use a time piece, taking the time of departure, the time of arrival and dividing the elapsed time by the number of miles traveled; for under ordinary driving conditions, it is impossible to drive a car at a uniform rate of speed.

Bullets have no speedometers on them, nor do they travel at a fixed rate of speed and their velocities must be measured with an instrument that measures time; the time required for the bullet to travel over a known distance. To measure the velocities of bullets and projectiles, instruments known as chronographs are used, their name signifying the graphic measurement of time.

The instrument most used for this purpose is the Boulengé chronograph, the invention of a Belgian army officer whose name it bears. This chronograph has been modified in several ways during the many years it has been used but the fundamental principle is still retained, viz.; the measurement of elapsed time through the medium of two falling weights. The design and operation of this instrument can be understood from the accompanying simplified diagram.

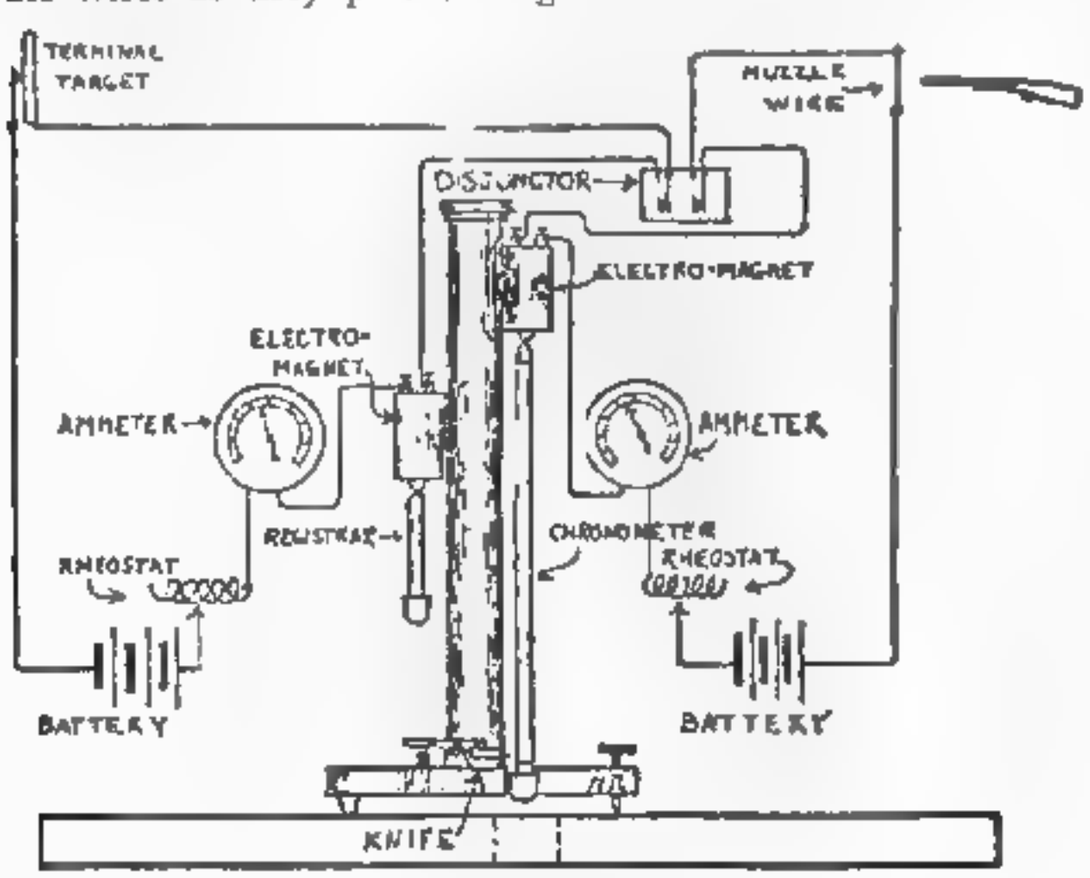
The instrument consists of a solid base mounted on legs that can be adjusted to level it and set on a solid bench. The base supports a substantial vertical column about three feet high to which are attached two electro-magnets, one higher than the other. The circuits for these two magnets are independent of one another but a means is provided interrupting both circuits at the same instant, in order to obtain a zero point. This device breaking both circuits at once is called the "disjunctor." Their cores are, of course, only magnetized while the electric current is passing through them and must be uniform as to magnetic "lag,"

or the retention of magnetism, after the circuit is broken. 91
A long, steel rod called the "chronometer" is suspended from the high magnet and a short one called the "registrar" from the low magnet. Both rods have soft iron tips that demagnetize quickly. A copper or zinc tube is slipped over the chronometer rod and extends nearly the length of the rod. This tube is called the "recorder" and, when in place, the weights of the two rods are the same, or about one pound each.

On the base is a knife actuated by a spring and so located that the chronometer, in falling, passes close to its edge when the knife is cocked. The knife is held in the cocked position by a flat, plate-like trigger which extends under the registrar.

The current is usually supplied by storage batteries and passes through rheostats and ammeters connected in the circuits of each of the electro-magnets. By means of the rheostats and ammeters, the strength of the current and consequently of the magnetic fields can be equalized in both magnets, so that each will lose its magnetism at the same speed when the circuit is broken.

While the circuits through the two magnets are independent of one another, they both pass through the disjunctor, whereby both circuits may be broken at the same instant. The independent circuit of the magnet supporting the chronometer rod passes through a fine wire, called the muzzle wire, stretched across the path of the bullet and located close to the muzzle of the gun. The circuit for the registrar magnet is completed through a circuit interrupter placed at some distance from the muzzle of the gun. For measuring the velocities of small arms bullets, this interrupter usually takes the form of a piece of armor plate with a hardened surface that will not be deformed by the repeated impact of bullets, having a delicate adjustable spring contact on its back. The adjustment of this spring contact is so delicate that any jar of the plate will cause the circuit to break. The spring causes it to remake contact immediately, which eliminates any need of manual operation and saves time. In measuring the velocities of artillery pro- 92
jectiles, two wire screens are used, the projectiles breaking the wires as they pass through. Such screens must be re-



The Boulenge chronograph "hook-up" before the shot has been fired.

paired or replaced after each shot and in small arms work are not often used except for armor piercing bullets.

After the chronograph is adjusted and before doing any firing, the chronograph and registrar rods are "hung up" on their respective magnets and both circuits are broken at the same instant by means of the disjunctor, so that both rods will fall at the same time. When the registrar strikes the trigger, the knife is released and flies out, making a cut or nick on the recorder or tube carried by the chronometer rod at the point which is opposite the knife at that instant. The distance that the chronometer drops before the knife strikes it represents the free fall and will be constant from one shot to another. The mark made on the recorder is the 93
zero mark, or disjunctor point, from which subsequent measurements are taken.

The rods are then hung up again and a shot fired. The instant the bullet breaks the muzzle wire, the circuit in the chronometer magnet is broken and the chronometer rod begins to fall; and when the bullet strikes the terminal target, breaking the circuit in the registrar magnet, then the registrar falls. Both rods continue to drop together but when the registrar strikes the trigger, the knife flies out and cuts a nick in the recorder at the point opposite the knife edge at that instant. The distance between the zero mark and the one made by firing represents the time required for the bullet to pass from the muzzle wire to the terminal target and as this distance is definitely known, it is a simple matter to calculate the time of flight and the velocity in feet per second. As a matter of fact, such calculation is not necessary as the scale with which the distance between the marks is measured is graduated to read directly in feet per second, thus saving a lot of time and trouble.

In taking rifle velocities, the muzzle wire is located three feet in front of the muzzle to avoid its being broken by the muzzle blast. The terminal target is located 150 feet from the muzzle wire and this distance, plus the distance from the muzzle of the rifle to the muzzle wire makes a total of 153 feet that the bullet travels, although the velocity is measured only over 150 feet. In this case the velocity obtained is the average over the 150 feet between muzzle wire and terminal target, and is the velocity at the midpoint of this distance, or at 78 feet from the muzzle. Sometimes the terminal target is placed 100 feet in front of the muzzle wire, giving a velocity at 53 feet from the muzzle; or any other convenient distance may be used.

For pistol or artillery velocities, the distances are smaller and greater respectively and each measuring scale is stamped with the distance between "screens" that it is suited for.

Velocities taken as described are the average velocities 94
over the distance and are called "instrumental velocity." As a bullet begins to slow up once it is beyond the influence of the muzzle blast, it is not traveling as fast when it strikes the target as when it left the muzzle of the arm it was fired from. It is a difficult matter to find the exact velocity of a bullet at the instant it leaves the muzzle of a rifle, but it can be found approximately as follows:—Mark one horizontal edge of a sheet of cross section paper off in units of feet, starting with zero at the right to represent the muzzle

of the gun and continuing to the left, say, in increments of ten feet each, running up to at least eighty feet. The right hand vertical side of the sheet should be marked off in units of velocity. Fire a series of shots at 78 feet in the usual manner and plot the result as one point of a velocity-distance curve. Then move the terminal target up to about 38 feet from the muzzle, fire another series of shots and plot a second point on the cross section paper. Now, connect the two points and extend the line to the right until it reaches the zero, or muzzle point, and you will have the approximate muzzle velocity. A more accurate result can be obtained by firing the series at a greater number of different distances but two points will prove fairly accurate; at least much more accurate than guessing.

A Boulengé chronograph, in good condition and carefully adjusted, can measure such short intervals of time as that between the time the trigger is pulled and the time the bullet leaves the muzzle of the barrel. Such a fine adjustment is hardly necessary for routine testing of ammunition, but is a virtue in testing powder lots. The powder companies will take the velocities of hand loaded ammunition for any handloader of an experimental turn of mind, at a very reasonable charge.

The Aberdeen chronograph is also used to a limited extent for measuring bullet velocities. This apparatus takes the form of a synchronous motor, mounted with the shaft in a vertical position. To the shaft is assembled a shallow pan or metal dish with straight sides, carefully turned and balanced.
This pan carries a strip of thin paper equal in length to the 95
inside circumference of the pan. Instead of two weights, two points are located, one just over the other and close to the pan wall. These points are connected to separate electrical circuits, one passing through the muzzle wire and the other through the disjunctor. The bullet, on breaking the muzzle wire, causes a spark to jump from its point to the wall of the pan, burning a tiny hole in the paper and when the bullet strikes the disjunctor, a second spark jumps through the paper. The distance between the two holes is an indication of the instrumental velocity. It can be seen that the accuracy is dependent upon the pan rotating at a proper and uniform speed and if it does this, the paper can be (and is) marked off with lines so that a direct velocity reading may be taken from it.

A synchronous motor is one especially wound to maintain a uniform number of revolutions per minute, regardless of fluctuations in the line voltage. Actually, it does not do this but will lose or gain more or less speed as additional load is taken off or put on to the line the motor is running on. What it does is to adjust itself to these changes and return to its normal speed. These temporary fluctuations in speed are of no consequence for all ordinary purposes, but they are fatal to the taking of accurate velocities. An Aberdeen chronograph would be of little use if hooked up on a city line, especially a power line. If the lady next door turned on her electric stove just as a shot was fired, the reading of velocity given by the instrument would be worthless. These chronographs are at their best when operated by a separate generator of their own and on a line which is not used for any other purpose. Under such a condition, very accurate results can be obtained with them.

Preparation of Tables of Loads.

In working out their tables of charges, the powder companies use new, primed cases purchased from the commercial ammunition companies or, in the case of the Cal. .30-06 cartridge, from Frankford Arsenal. These cases are primed
96 with the primers that the manufacturer uses in loading his own ammunition and most of these primers are different from those sold for reloading purposes. The flash holes in the cases are made of a correct size for the primers used, but the use of a primer of different make from the cartridge case can give a very different order of ignition to the powder charge. All cartridge cases of the same caliber are not of the same capacity; some have thicker side walls and thicker heads than others. As the *outside* dimensions must be the same, within very close limits, any variation in the thickness of the metal in the cases will mean a variation in their internal volume. If two cases of different thicknesses are loaded with the same charge of powder, one will have a higher density of loading than the other and will consequently develop a higher pressure. Between the differences in cases and primers, it is a matter of chance if a handloader gets the same velocity and pressure from his reloaded ammunition that the powder manufacturer got, even though the handloader is meticulous in the preparation of his ammunition. The nearer the load is to the maximum *recommended* load for any cartridge, the more marked will be the effect of variations from the conditions under which the load was worked out. Any difference in bullet weight, diameter, shape, or hardness will also affect the ballistics.

In addition to variations in components, there are the guns to be considered. Chambers vary in size and shape and ammunition fired in an arm having a tighter chamber than the test gun will develop a higher pressure. The same is true if the bore and groove dimensions, and especially the throating of the barrel, are tighter or smaller.

Powder for testing purposes is kept in rooms or magazines, where the temperature is maintained at a uniform level, and tests for velocity and pressure are made with the powder at 70° F. Any increase in the temperature of the powder will cause it to ignite more easily and to burn more rapidly, thereby causing a rise in the chamber pressure above the expected point. Exposing ammunition to the hot
97 sun long enough to heat up the powder charges will usually produce some surprising results and doing this with some cartridges has been known to increase the pressures over 10,000 pounds per square inch. Maximum charges, which are much in the nature of "proof charges" to begin with, will certainly become more dangerous if warmed up before firing.

The powder boys know these things and state very clearly in their folders and booklets of tables of charges that the figures shown are those obtained with the arms and components that *they* used. They further recommend that charges below the maximum *recommended* charges be used for the best accuracy and that in rifles with tight chambers the heaviest charges should be reduced several grains in weight. This is excellent advice to follow.

The tables of charges published by the powder companies

give either the seating depth of the bullets or the over-all length of the cartridge for each load listed. This is done to show the condition under which the ballistics were developed. In the moderate and reduced loads, the exact seating depth of bullets is not of great importance, but it becomes of increasing importance as the charges approach the higher levels. With the heaviest charges shown in these tables, the bullets should never be seated deeper than the dimensions given in the tables. With full charges in such cartridges as the .220 Swift, .257 Roberts, or any others in which the cartridge is a close fit in the chamber, especially at the neck, even a few thousandths of an inch increase in the seating depth of the bullets will cause an appreciable increase in the chamber pressures.

If the reader believes from the foregoing remarks that the writer is a timid soul or an alarmist, he is mistaken. Variations in components such as primers, flash holes, volume of cartridge cases, etc., are matters a handloader seldom thinks of. To the average person, all cases of the same caliber are alike and a primer is a primer; just a little dingus that makes the cartridge explode. There is a lot more to them than that and while their variations can 98
cause lower pressures, as well as higher ones, than are indicated in tables of recommended charges, their effect in a minus direction has been skipped over because it doesn't involve the matter of safety. Even when these variations operate to increase pressures they are not likely to result in dangerous pressures if the handloader observes carefully *all* of the information given in the tables.

In manufacturing arms and ammunition there must be manufacturing tolerances and all arms and ammunition of the same caliber are not exactly alike nor are the components that go into the manufacture of the ammunition alike. Bullets will vary a little in diameter and weight, and primers, however good they may be, will not be absolutely uniform from one lot to another.

In the establishment of pressure limits for different arms, experience has dictated a limit for each caliber, make or type that should not be exceeded. This maximum pressure limit is not necessarily close to the bursting point of the gun. As a matter of fact, no one knows what the bursting point of a gun is. One arm may stand a prodigious charge of powder, while another of the same make, model and caliber lets go with what appears to be a perfectly normal charge. Maximum pressure limits are established, however, to allow a reasonable margin of safety, to take care of the unavoidable variations in ammunition and ammunition components. One primer out of ten thousand or more may give an exceptionally hot flash and over ignite the powder charge. A cartridge case may have a hidden flaw that can not be seen by the inspectors, or an over-size bullet may get into a cartridge, to say nothing of errors in powder charges. The margin of safety is left to protect the shooter who may happen to shoot a faulty cartridge once in a while and in loading ammunition the handloader should guard against any encroachment on this margin of safety; it is the most important part of a firearm. All is not gold that glitters and all ammunition components are not alike just because they look alike. To load ammunition intelligently, especially the 99
heavier loads, one must know what he is dealing with.

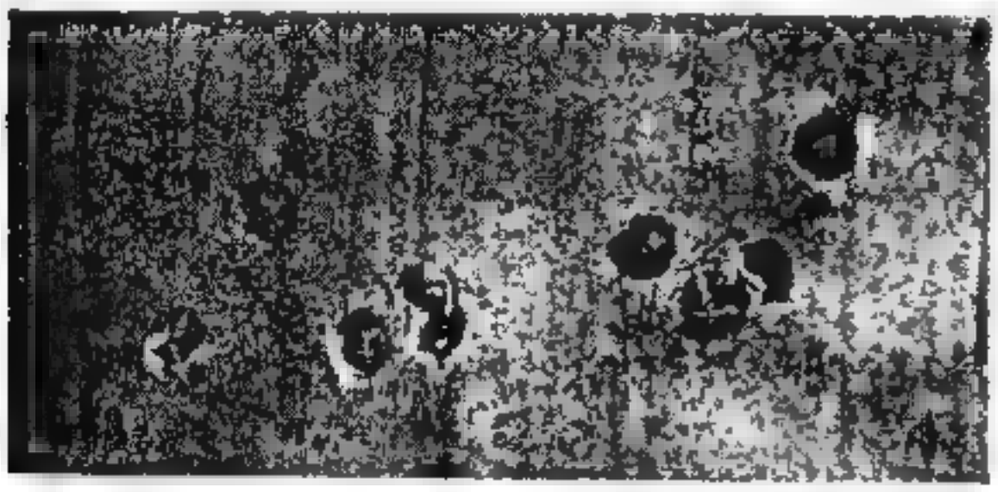
Maximum Loads.

Maximum loads are those that exceed the limits of pressures prescribed by experience and intelligent ballistic determinations. They are over-loads and are therefore dangerous. Sometime, someone lit on the not particularly bright idea that some arms are stronger than others using the same caliber of cartridge and that the ammunition manufacturers load their ammunition to be safe in the weakest arm of each caliber. It is true that some arms are mechanically stronger than others but regardless of the arm, it is the cartridge case which has to hold the gasses in. The idea that the ammunition manufacturers load for the weakest arm of each caliber is pure fiction. There are plenty of imported arms in use which have such narrow margins of safety that they ought not be fired with normal loads. Just as one example, do you believe that any cartridge manufacturer loads his ammunition to be safe in the pot metal Spanish guns with which the American market was flooded shortly after the War? Of course not! And plenty of this junk has popped open like a jack-in-the-box with perfectly normal ammunition. Ammunition is loaded by the factories to the highest level of pressure that will be reasonably safe under the varying conditions of use it is likely to be subjected to, IN GOOD ARMS THAT ARE IN GOOD CONDITION. The effect of the improvements that have been made in alloy steels and the additional strength of arms resulting from their use has been to increase the margin or factor of safety and to decrease the number of accidents that occurred with older arms. In spite of this increased strength, accidents will occasionally occur with factory loaded ammunition.

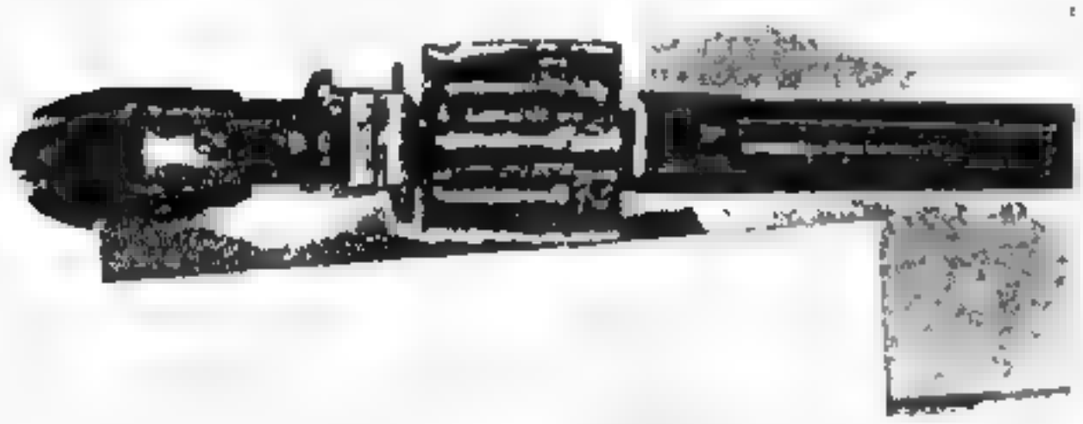
Before we get too far away from the subject, let's take a look at the .30-06 cartridge. This cartridge was developed as the standard military cartridge for the armed forces of the United States. It was especially made to be used in the
100 Model 1903 Springfield rifle and that rifle is one of the strongest there is. Every rifle taking the .30-06 cartridge that has been brought out since the Springfield made its debut *has been built to hold the cartridge*. The cartridge has *not* been loaded to suit these rifles. This is true of many other calibers as well. The Springfield rifle has been loaded with prodigious loads of many kinds of powder and has withstood them in laboratory tests, yet these rifles occasionally blow up in service with apparently normal loads—and so do all other rifles.

Now, it is well for the reader to bear in mind that there is a big difference between a wrecked and a blown up rifle, or any other type of firearm. A wrecked rifle is one that is destroyed by *any* cause when fired. A blown up rifle is one that is wrecked because of a mechanical or structural weakness in the arm itself. For example, a cartridge case may give way at the head and blow a firearm all to hell, but such a blow is the fault of the cartridge case or load and not due to weakness in the arm. If the shoulders supporting a breech block shear off or a firing pin blows out with a normal load, that is the fault of the arm. The difference is a technical one and of little interest to the shooter who has his puss parked alongside of the action when it lets go, but when you hear of any rifle not blowing up under excessive pres-

sure don't try to duplicate the load used with the belief that the rifle used in making the test remained intact. Even if it did there would be no object in duplicating the experiment.



A crude test of primer performance. Two "groups" made by firing the primers from the inside of the cup. Note the deep penetration of the left hand group. This indicates violence but the primers in the right hand group were, by far, the best ignitors of the two.



A revolver blown up by the effects of three overloaded cartridges. Note that the set-back from the fired cartridge also exploded the two lying on both sides the top one.

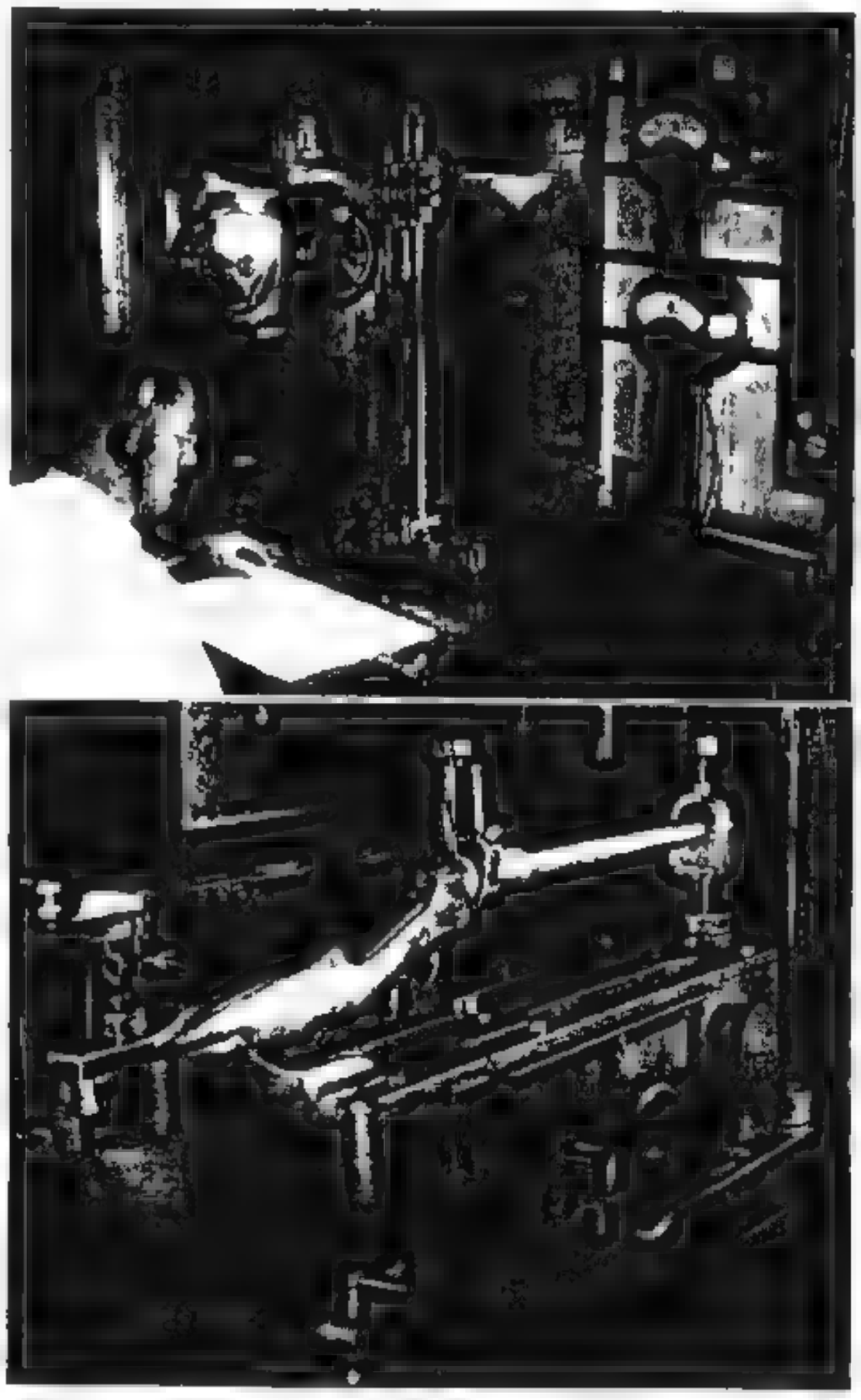
PLATE XI.

The Model '95 Winchester was chambered for the .30-06 cartridge and while its action was not as durable as that of a bolt action rifle, it was safe with this cartridge, provided the action was in reasonably good condition. In a sense, the '95 would not stand what the Springfield would and some time someone got the crazy idea that when ammunition was reloaded for the Springfield, it could be loaded to much higher pressures than for the '95. No doubt this was on the erroneous theory that the factory cartridge was loaded for the '95, which was not quite as strong mechanically as the 101 Springfield.

If the reader will just stop and think for a moment he will realize that the ammunition business is a highly competitive one. Each manufacturer is constantly trying to get the jump on the other with some new bullet, load or cartridge and, whether it be for better or for worse, one of the things which most quickly causes the shooting public to quit one brand of ammunition and turn to another, is velocity. The minute a manufacturer announces a load that will develop a few foot seconds higher velocity than that of his competitors, the boys flock to his banner.

But, are experience and judgment thrown to the four winds just to get a little more velocity? They are not! The ammunition makers know that to exceed the prescribed limits of pressure for any cartridge will result in a flock of nice fat damage suits from those using the ammunition because of injuries received from its use.

Now let us look at the tables of powder charges published by the powder companies. These companies depend for their livelihood on the sale of powder and the more powder they sell, the better their business is. They would be tickled to pieces to tell you to stuff your cartridge cases full of powder, in order to increase the consumption if it were safe to do so. They prepare their tables with exacting care, using the best of laboratory testing equipment and personnel that have had years of experience. The heaviest loads in any of these tables *are the heaviest loads that should be used under any circumstances* and they are not for the novice at reloading to monkey with.



Apparatus for the taking of pressures and velocities. Upper view shows chronograph room of the Hercules Powder Company's ballistic station at Kenvil, N. J. Chronograph is set for the taking of time interval as soon as the shot is fired. Lower view shows firing point with rifle set in the rest for taking of both velocity and pressure. Rifle is special pressure gun with yoke mounted over the chamber for the taking of pressures by radial system.

PLATE XII.

In developing any new factory cartridge, the ammunition and powder companies work very closely together to develop a suitable powder. When the desired velocity has been obtained with apparently safe pressures, a small lot of the

ammunition is loaded and sent to different parts of the world so that it may receive a practical test under different climatic conditions. Sometimes it is placed in storage at different points and later re-tested for possible ballistic 102
changes. When it appears that the product is satisfactory, a run is made and sent out to the trade, a careful record being kept of the dealers or sections of the country that it goes to. This lot will carry a distinctive code number. If complaints come in from shooters, the manufacturer always wants to know the code number on the box the cartridges were taken from and if the complaints are numerous or serious, that lot of ammunition is withdrawn from the market and the source of trouble eliminated before any more is sent out.

That is just a brief example of the care that must go into the manufacture of ammunition if it is to be safe under average conditions and this general procedure is necessary because of the high levels of pressure to which factory ammunition is loaded. In spite of all the testing facilities and the care taken during manufacture, plenty of lots of ammunition have had to be recalled and salvaged. New loads have been worked out, and even new cartridges, and after tests and trials they are put on the market. The catalogues and ballistic tables are published and tons of cartridge boxes printed showing the velocity developed by the ammunition that is to go in them and then trouble develops. That ammunition has to be called back and salvaged. The powder has to be changed and the load reduced, with a resultant loss in muzzle velocity, but the advertising is out and there is no use crying about it. There are and have been many cartridges that don't develop the advertised velocities, just for this reason and not because of intentional deception on the part of the manufacturers. And what difference does it make? None at all The ammunition is accurate, it shoots flat and it kills game nicely and if it does that what difference does a hundred foot seconds or so mean?

If these things happen when all the facilities of an ammunition factory and two or three ballistic laboratories are used, where does the handloader get off when he starts monkeying with maximum loads? As a matter of fact, he usually gets away with it, which bears out the old adage 103
that "the Lord looks out for fools and little children."

There is usually at least one barn-yard ballistician in each shooting community who delights in overloading his ammunition. You can always tell when one of them is around, for his first act on arrival at the range is to tell everyone who will listen to him how much powder he is using. After he feels that the assembled multitude is duly impressed, he steps up to the firing point and touches off something with a muzzle blast that would make Gabriel's trumpet sound like the peep of a canary with tonsilitus. And the bullet, upon reaching the paper target some two hundred yards away, passes completely through it instead of bouncing off as any ordinary bullet might do! Then the mighty magician turns around with a triumphant air and awaits the applause, which is usually lacking

Engaging this person in conversation will probably disclose the fact that what he knows about ammunition can be written on the back of a postage stamp and leave room for the Lord's Prayer besides. And the pity of it is, that it isn't his fault. He is probably only trying to duplicate a load he has read about in some magazine article that ought never to have been published. Time and time again, I receive letters very much as follows:—"I have just bought a rifle for the ———— cartridge and want to reload my own ammunition. What tools do I need and what is the maximum load I can use in this cartridge?" Now there's a combination for you! A guy who doesn't even know enough about reloading to pick out a set of loading tools, wanting to load dangerous loads! I believe that the responsibility for this dangerous propaganda lies squarely with the gun editors, past and present, of our shooting magazines who, either because of their own limited experience or lack of thoughtfulness, recommend maximum loads or permit articles to be published that do recommend them.

When we have a kink in the gut we call a doctor and when we want our teeth fixed we go to a dentist and we
104 don't argue or disagree with their findings, because we know that they know a lot more about their profession than we do. Yet, when we read of some heavy load of powder that hasn't happened to do any damage, there is a strong inclination to disregard the source from which the information comes, unreliable and irresponsible as it may be, and to figure that this great discovery is something that the powder boys overlooked. The place to get authentic information about powders and loads is from the powder companies, and their folders or tables of charges have been prepared with no other purpose than to give it to you.

Having given maximum, or over-loads, about 1% of the condemnation they deserve, and without the use of profane language, permit me to say that this is not a condemnation of the use of any load or loads used in the process of intelligent experimentation. In the loading of ammunition as in all other things, there would be no progress if we were always to abide by the present accepted order of things. Some very important advances in the art of ammunition manufacture have had their origin in the experiments of handloaders with a yen to find out things for themselves and the education and intelligence to do the finding out in an orderly, reasoning manner. Such experiments are by no means limited to high pressure loads, but high pressures are likely to be encountered when experimenting with the unknown. However, the field of experimentation is not for the average handloader and especially not for him who hasn't the money to do it properly, for it is often an expensive game to play. The experimenter should realize that working with high pressure loads is a dangerous game and conduct himself accordingly, proceeding slowly and collaborating with those who are likely to be able to steer him away from pitfalls.

Therefore, anything I have said against maximum loads is not intended to apply to the experimenter but rather to the every-day reloader who is just reloading his ammunition for ordinary shooting purposes. Maximum loads will give
105 very little more velocity than ordinary full loads, but much higher pressures. They are less accurate than normal loads and especially so over the ranges at which most reloaded ammunition is used, and there is no reason or excuse for their use.

The Use of Tables of Charges.

Tables of charges can be divided into two classes; those published by the powder companies and those found in handbooks on reloading. In preparing their tables of charges, the powder companies fire the ammunition for velocity and pressure only. They do not always fire it for accuracy, but because of the similarity of some of the loads to those used by the ammunition companies, plus an extensive experience, the loads published in their tables will be found to give good results. The heaviest charges given are merely to show the limit *that should not be exceeded* and will not necessarily give the best of accuracy.

The tables in handbooks are for the most part loads that have proven accurate in actual use and which have been checked with the powder companies for accuracy and safety. The loads taken from either of these sources can be relied upon for safety, if the loading conditions are duplicated.

In addition to these tables, there are the loads which are described in magazine articles. Most of these are good, but charges taken from such sources are the least reliable of the three.

Every reloader should have in his possession the tables of charges published by the powder companies for the powder or powders that he is using, and he should renew his file of these folders about once every year, for, as we have seen, different lots of the same kind of powder are apt to differ in characteristics and the powder companies make up new tables when a new lot of powder requires a change in the charges. One will sometimes find a discrepancy in the weights of charges in two or more different tables, all giving different weights of charges for the same cartridge, bullet, and velocity. This is because the results published 106
are based on the use of different powder lots.

For the benefit of the inexperienced, it is not the best idea to get all the folders and tables from the powder companies, but only those relating to the powders suitable for the cartridge or cartridges which are to be reloaded. Naturally, the beginner at the handloading game does not know much, if anything, about the many different kinds of powder that there are and consequently doesn't know what to ask for. The information which should be given is as follows: The manufacturer's designation of the cartridge the powder is to be used in. This is essential and it is sufficient in the case of a pistol or revolver cartridge. But if one is reloading rifle ammunition, certain additional information should be given.

In this case, state whether you wish to reload with reduced or full charges and also indicate whether you are going to use plain base or gas-check cast bullets, jacketed bullets, or all three. This data will enable the source of information to send material which will be of real use to you, rather than just a handful of literature that may prove confusing and result in your selecting a powder other than the best one for your purpose.

Some powders, because of the high pressures under which they must be burned to perform properly, can only be used with jacketed bullets. Others having a wider tolerance may be used with both jacketed and plain base bullets, while still others suitable for gas-check bullets can also be used with plain base bullets as well. There are powders which should be used only with jacketed bullets in the smaller cartridges that are excellent for reduced loads using cast bullets in the larger cartridges. These powders are so numerous and overlap one another so that there is no use in attempting to lay down definite rules regarding them but if, in inquiring for powder folders containing tables of charges, you give the proper essential information as suggested above, you will give the fellow who gets
107 your letter a chance to send you something that will be of real help.

If you are a beginner at the game, you will still be in something of a quandary as to which one to select. To make a proper selection isn't as difficult as might appear at first glance for, *the most efficient powder for any cartridge with any kind or weight of bullet is the one that will give the desired velocity with the lightest weight of charge.* This does not refer particularly to a comparison between single and double base powders and the rule is applicable to either kind. Now, let's take a concrete example to see just how this rule works out.

I am just breaking in to the reloading game and am all pepped up about it. I have just received a nice, shiny Model 1917 rifle that cost me six and a half bucks, some 173 grain boat-tail bullets, and some F.A. No. 70 primers that I purchased through the Director of Civilian Marksmanship, also a set of reloading tools. I have some empty cartridge cases and I'm all-atwitter to get to shooting and show the boys how good I am, but I don't know just what powder to use. Of course I don't want any squib loads because them's only for kids, nor do I want any maximum loads, but I do want something with some soup behind it to make the boys sit up and take notice. S—o, I'll use the heaviest load that the powder tables give and be very careful about the way I load it. So far, so good.

I have a pretty red, white and blue book that I got from the duPont Co., so I sit down to apply the above rule, picking out the heaviest loads permissible for use with the 173 grain boat-tail bullet and this is what I get:

I.M.R. 4198	39.5 Grs.	2615 f.s.
I.M.R. 3031	48.5 Grs.	2800 f.s.
I.M.R. 4320	51.0 Grs.	2860 f.s.
I.M.R. 4064	51.0 Grs.	2820 f.s.

It is quite clear that the choice for the kind of a load I am looking for, lies between No. 3031 and No. 4320 powders. I.M.R. No. 4320 will give me the higher velocity
108 of the two but it requires 2.5 grains more than No. 3031 to give me only 60 f.s. more velocity and 60 f.s. isn't a whole lot more than the normal fluctuation in velocity that is permissible from one cartridge to another, furthermore, that much difference doesn't amount to a hill of beans at such a high velocity. So No. 3031 is the most efficient of the two and that is the powder I buy.

The ammunition loaded, I repair to the range and blast away at the two hundred yard target, and with very good results. I am elated! New gun, swell ammunition 'n'everything, when along comes a guy. (To avoid a fight or an argument, "the guy" will be me also.) I roll over on my

side and remark, "Got a new gun. How'm I doing?"

"You're doing alright but what in hell have you got in that ammunition?"

"Why! 48.5 grains of 3031; ain't that alright?"

"Sure", says the guy, "but it's going to wear all the hair off your belly; it's shoving you back about six inches every time you shoot. If you load that bullet down to about 2200 foot seconds, you'll get better accuracy at this distance and save yourself some money to boot."

Ain't that something! Here I was, sitting on top of the world, and this guy has to send the enthusiasm in my thermometer down about thirty degrees, but my shoulder *is* commencing to feel it and for some reason or other my lip is swelling up, so when I get home I take another look at the red, white and blue book to see what load will give me 2200 f.s. velocity.

Powders Nos. 4064, 4320 and 3031 don't show any charges giving velocities as low as 2200 f.s. and I don't know whether or not I will get complete combustion and uniform burning if I go below the limits shown, but No. 4198 shows a charge of 25.0 grains giving a muzzle velocity of 1830 f.s. and another of 39.5 grains giving 2615 f.s. As these loads in the .30-06 cartridge, with the 173 grain boat-tail bullet, approximately represent the tolerance of the powder, the velocity curve will, no doubt, show an orderly and fairly uniform progression in velocity for each grain increase in the powder charge between these limits. I can plot these points on cross-section paper as already described, and pick out my load but I haven't any cross-section paper, so I interpolate in the following manner, figuring to the nearest tenth of a grain weight of charge and to the nearest foot-second:

	39.5 Grs. gives	2615 f.s.
—	25.0 Grs. gives	1830 f.s.
The difference is	14.5 Grs.	785 f.s.

Dividing 14.5 into 785 gives the change in velocity for a change of one grain in the weight of the powder charge or, in this instance, 54 f.s.

I want a load that will give 2200 f.s. 25.0 grains of 109
powder gives 1830 f.s. and deducting this from the desired velocity gives a difference of 370 f.s.

As 54 f.s. equals the change in velocity for one grain of powder, dividing 54 into 370 will give the increase over the 1830 f.s. load to bring the velocity up to 2200 f.s. This figures out 6.8 grains which, when added to the 25.0 grains necessary to develop 1830 f.s., gives 31.8 grains. Therefore, a load of 31.8 grains will give me 2200 f.s. muzzle velocity.

This simple method, while not always giving precisely accurate results, will give a very close approximation. All that is necessary is to have two charges of the same kind of powder for the same cartridge and bullet. Nothing must differ except the weights of the charges. In explaining it, the object has not been to teach common arithmetic, nor to insult the reader's intelligence, but to show that the efficiency and suitability of a powder does not depend upon the caliber of the cartridge and the kind and weight of bullet alone, but on the desired velocity as well.

Charges for Gas-check Bullets. Some powder tables do not give charges for gas-check bullets but not infrequently the powder that the table pertains to can be used with such bullets and with entire success. Of course, where
110 loads are given for gas-check bullets, the same rule given above can be applied in selecting the most efficient powder, not overlooking the desired velocity in applying it. But gas-check loads can also be picked from some tables of loads for jacketed bullets. For this purpose, velocity figures are much more useful than those for pressures, because the performance of gas-check bullets depends much more on the velocity at which they are driven than upon the pressures developed behind them. While no definite rule can be given as to the velocities at which gas-check bullets may be driven, 1800 f.s. is a reasonable and conservative limit. Actually, some of them can be driven at well over 2000 f.s. with good accuracy; it all depends upon the caliber and weight of bullet, the alloy from which it is cast, the amount and kind of lubrication it carries and the arm in which it is fired. Some gas-check bullets will shoot with extreme accuracy in a 30 inch barrel if driven at moderate velocities yet, if they are speeded up, they cause leading near the muzzle and become very inaccurate. The same bullet can be fired at a much higher velocity in a 24 inch barrel because, in spite of the additional friction and heat from the increased charge, the lubrication is not exhausted before the bullet leaves the muzzle of the shorter barrel.

To pick a load for a gas-check bullet from a table of charges for jacketed bullets, select a load for a jacketed bullet of approximately the same weight as the gas-check bullet, that gives a muzzle velocity of about 1800 f.s. If the velocity shown is a little higher than this, it doesn't matter and the load may still prove to be a very good one. After all, the only way to find out whether any load is accurate or not is to fire it.

There is one thing to bear in mind in selecting loads in this way. Any cast bullet, however hard the alloy may be from which it is cast, is soft in comparison with a jacketed bullet. It requires less force and less time for the powder gases to impress it into the rifling of the barrel, which means that the lead alloy bullet will accelerate faster
111 than a jacketed bullet of the same weight. Because of the lesser resistance and quicker forward movement of the alloy bullet, the chamber pressure will not be quite as high as with a jacketed bullet and because of the more rapid acceleration of the soft bullet, its muzzle velocity will be higher. In other words, all other things being equal, a gas-check bullet will develop a lower chamber pressure and a higher muzzle velocity than a jacketed bullet. The rule is not inflexible but the exceptions to it are few and far between. A comparison can not be made between a gas-check bullet and a boat-tail bullet because the latter has a short bearing surface for its weight, but the rule holds up well in comparisons with flat base jacketed bullets. For example, I have a table of charges in front of me now and find these comparative velocities for a certain cartridge:

150 grain jacketed.	16.0 grains	1320 f.s.
154 grain lead.	16.0 grains	1460 f.s.

In spite of the slightly heavier lead bullet, the same powder charge gives it 140 f.s. more velocity than the jacketed

bullet.

At the higher velocities, where the chamber pressure builds up quicker, the difference between the velocities of the two different types of bullets is less marked and occasionally, charge for charge, the jacketed bullet will have slightly the higher velocity of the two. This may very possibly be due to the severe upsettage of the softer bullet but, at any rate, when this condition does occur, it is at velocities above which gas-check bullets can be expected to shoot accurately

Naturally, some powders are much better adapted for use with gas-check bullets than others and those powders should be used wherever possible. The only object in suggesting a means of selecting less desirable powders, such as those intended for jacketed bullets primarily, is because we often have to make the best use of what we have, regardless of whether there is something better elsewhere.

Loads for plain base cast bullets can be picked from tables of charges for powders not particularly recommended 112
for such bullets, by the means described above, but the velocity limit for plain base bullets can, for this purpose, be placed at 1600 f.s.

Powders that do not meet the limits of velocity suggested for cast bullets can sometimes be used with pretty good results, but this is getting pretty far from the path of righteousness. To use any of the military powders with plain base cast bullets is almost foolhardy, in a land where powders are as easily obtainable as here in the U. S. Always use the correct powder for your purpose, if you can possibly get it.

Incomplete Combustion. As has been previously pointed out, each kind and type of powder has a range of pressures over which it burns uniformly, this range being known as the tolerance. Past the upper end of the tolerance of a powder, erratic and dangerous pressures may occur but there is no danger at all connected with loading them below the lower limit. The evil in this direction is poor burning and incomplete combustion. The line of demarkation at the ends of the tolerance is less sharp at the lower end than at the upper; it tapers or shades off into an unsatisfactory condition. Therefore, loading to a little lower velocity than is indicated in the powder tables may give very good results. The charges may not burn completely but if the burning is uniform from one cartridge to another, the accuracy will still be good. But in using charges that are likely to develop velocities appreciably below the lowest levels shown in the tables, the reloader should watch his barrel carefully and clean it well after firing, regardless of the type of primer used.

The products of combustion of all smokeless powders when burned completely are nitrogen, hydrogen, carbon dioxide, carbon monoxide and water, the latter in the form of vapor. When the combustion is not complete, that is, when smokeless powder is burned at pressures below normal, a residue is sometimes left that will cause rapid oxidation of the barrel steel. I have, by burning powder at a 113
pressure about 10,000 pounds below its tolerance, produced streaks and roughness in the throat of a barrel by firing as few as fifty rounds. The condition appeared much worse when the barrel was viewed from the breech in the ordinary manner, than after it was sawed in two. I was able to produce approximately the same effect on the barrel by the application of a diluted solution of nitric acid, so believed that the original condition resulted from the products of incomplete combustion combining with atmospheric moisture to form traces of a dilute acid, but this theory has been disputed by authorities who know more about it than I do. It is not the purpose here to enter into a discussion of the physics or chemistry, but rather to point out the possibility of injury to a barrel from using high pressure powders in too greatly reduced charges.

Notes on the Selection of Powders.

Black sporting powder comes in three different granulations and the uses of the different granulations can be roughly classified as follows:

FFFg. This is the finest granulation of the three. It is suitable for use in revolver cartridges not exceeding caliber .38, having cartridge cases not more than ¾ inch long. It is also suitable for use in small rifle cartridges such as the .22 W.C.F., and other Cal. .22 center fire cartridges now obsolete, as well as in muzzle loading rifles up to Cal. .38.

FFg. This is the medium granulation and has the widest use. It is suitable for practically all rifle and revolver cartridges up to and including the .45 calibers, except for the small ones already mentioned. This granulation is also good in muzzle loading rifles of from Cal. .38 to .45.

Fg. This is the coarsest granulation of black powder. It should be used in all cartridges of a caliber above .45 except the .50 Remington Pistol cartridge for which FFg is better, and in all muzzle loading arms larger than Cal. 114
.45. It is especially recommended for old muzzle loading military muskets and is similar to what used to be known as "musket powder."

Kings Semi-Smokeless Powder. This powder is manufactured in a greater variety of granulations than black powder and no rule of thumb can be laid down as to the grain size that should be used for different cartridges. To list the calibers and appropriate granulation to use for each one would merely mean copying the table of charges published by the manufacturer. As this table can be had for the asking, there is no object in taking up space with its publictaion here.

Smokeless Powder For All Pistol and Revolver Cartridges. duPont pistol powders Nos. 5 and 6, and Hercules Bullseye are the powders best adapted for these cartridges for loads developing normal velocities or for reduced or mid-range loads. For so-called high velocity loads in revolvers, Hercules Unique will give the highest velocities with normal pressures. Unique, while essentially a powder for rifle cartridges of small capacity, has proven to be an excellent one for developing more than normal velocities in revolvers, but it is not recommended for normal or reduced loads in revolvers or pistols. duPont No. 80 can also be used in revolvers, although it is a rifle powder. If used in revolver cartridges it is, like Unique, at its best when used in the heavier charges, as the combustion is poor

at low pressures.

Therefore, he who wishes to reload revolver or pistol cartridges should obtain the powder folders covering those powders mentioned above and he will then have "the works." With them as a guide he can pick heavy or light loads and, so to speak, romp around to his heart's content within the prescribed limits of charges.

Smokeless Rifle Powders. Smokeless powders for rifles can not be described or disposed of with the same facility as the pistol powders. There are so many rifle powders, their latitude is so wide and they overlap one another to such an extent that any ordinary description 115
would be involved and inadequate. The following table is offered as an aid to requesting the proper powder *folders* or tables of charges for any or all of the most popular rifle cartridges in use at the present time. It does not include freak or special cartridges that are the handiwork of private experimenters, however virtuous they may be. Incidentally, whatever charm these cartridges possess in the way of extreme accuracy can be traced directly to the close relation of cartridge to chamber and throat, rather than to any black magic. This remark is in no way intended to reflect upon the private experimenter or any brain child that he may give birth to, because this type of individual, with his inquiring turn of mind, has contributed much to ammunition development. But this table is one of powder folders and it would serve no purpose to include cartridges for which there are no charges in the folders.

There are a few other points about this table that should be pointed out in order to avoid misunderstanding. The table shows some powders as being suitable for use with gas-check and plain base bullets, in spite of the fact that they do not contain specific loads for such bullets. An examination of these tables will show the reason for this by comparing the velocities of some of the jacketed bullet loads with the velocities permissible with cast bullets.

duPont No. 80 and Hercules Unique approximately parallel one another in their range of usefulness, in spite of their entirely different natures.

The paucity of loads for the duPont I.M.R. Powders is due to the omission of any cast bullet loads from the duPont tables and such loads have only been indicated where the information in the tables make it possible to do so. For example, I.M.R. Powder No. 4227 is similar in its application to Hercules No. 2400, but there is nothing in the tables to indicate such a wide usage.

On the other hand, the multiplicity of loads for the Hercules powders is not alone due to the wide tolerances of double base powders, but to the fact that loads of the 116
types indicated are given in the Hercules tables.

It is obvious, or should be, that where any powder is indicated as being satisfactory for jacketed, gas-check and plain base bullets, that this powder can not have the same degree of efficiency for all of these bullets but directions have already been given for finding out the most efficient powder for any type or weight of bullet.

For the sake of uniformity, tables have been indicated for the three types of bullets mentioned in spite of the fact that no gas-check bullets exist in a few of the calibers given.

In requesting powder folders, it is always well to state the caliber of cartridge or cartridges that you wish to reload, as complete tables of charges are available in individual form for some of the more popular cartridges. And besides, the powder boys are not sitting around in rocking chairs all day but are constantly getting out new "dope." What may be published today as the last word may not be correct tomorrow.

The tables only refer to those powders that are being currently manufactured and sold for reloading purposes by the powder companies. These are the best powders to use and are the ones that the reloader should endeavor to obtain. There are, however, other obsolete powders that can be used with entire satisfaction and as stocks of some of these powders are in the hands of dealers and more easily obtainable than some of the newer ones, the following comments are given on the more important ones as a guide to requesting tables of charges, where they are available.

duPont I.M.R. No. 1204. This powder has the same general applications as I.M.R. No. 4227 but is much less efficient and is useful principally with jacketed bullets because of its narrower tolerance. It can be used with cast bullets, in reduced loads, in some of the larger rifle cartridges, but the tables of charges for it do not contain any such loads. No more of this powder will be manufactured nor sent out by the manufacturer for reloading purposes.

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	DuPont Powders						Hercules Powders					
	I.M.R. 4227	I.M.R. 4198	I.M.R. 3031	I.M.R. 4320	I.M.R. 4064	80	Unique	Sharpshooter	Lightning	HiVel No. 2	HiVel No. 3	2400
22 Hornet, Jacketed	X					X	X					X
Gas Check						X	X					
Plain Base						X						
22 Hi Power Jacketed		X	X	X		X	X	X	X	X	X	X
Gas Check		X				X	X	X	X			
Plain Base						X						
220 Swift			X	X	X							
Gas Check						X						
Plain Base						X						
25 Rem.		X	X				X	X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
257 Rem. Roberts		X	X	X	X					X	X	
Gas Check						X	X					X
Plain Base						X	X					
250-3000		X	X	X	X		X	X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
25-20 Single Shot	X					X	X	X				X
Gas Check	X					X	X	X				X
Plain Base	X					X	X	X				X
25-20 Repeater	X					X	X	X				X
Gas Check	X					X	X	X				X
Plain Base	X					X	X	X				X
25-35 W.C.F.	X	X	X	X			X	X	X	X	X	X
Gas Check							X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
25-36 Marlin	X	X	X				X	X	X	X	X	X
Gas Check	X					X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
270 W.C.F.			X	X	X		X	X	X	X	X	X
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
30 Remington		X	X				X	X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
30-30 (.30 W.C.F.)		X	X				X	X	X	X	X	X
Gas Check		X	X			X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X

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	DuPont Powders						Hercules Powders					
	I.M.R. 4227	I.M.R. 4198	I.M.R. 3031	I.M.R. 4320	I.M.R. 4064	80	Unique	Sharpshooter	Lightning	HiVel No. 2	HiVel No. 3	2400
.300 Savage		X	X									
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
.300 H. & H. Magnum				X	X							
Gas Check												
Plain Base						X						
.30-06	X	X	X	X								
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
.30-40	X	X	X	X								
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
.303 Savage	X	X										
Gas Check	X	X										
Plain Base	X	X				X	X	X	X	X	X	X
.303 British		X	X	X								
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X		X	X
.32 Remington	X	X										
Gas Check	X											
Plain Base	X					X	X	X	X	X	X	X
.32 Win. Special	X	X	X									
Gas Check	X	X	X									
Plain Base	X	X	X			X	X	X	X	X	X	X
.32 Win. Self Loading	X											
Gas Check	X											
Plain Base	X					X	X	X	X			X
.32-20 (.32 W.C.F.)	X											
Gas Check	X											
Plain Base	X					X	X	X	X			X
.32-40	X	X										
Gas Check	X	X										
Plain Base	X	X				X	X	X	X	X	X	X
.33 Win.	X	X	X	X								
Gas Check	X											
Plain Base	X					X	X	X	X	X		
.348 Win.	X	X	X	X								
Gas Check												
Plain Base												
.35 Rem	X	X										
Gas Check	X	X										
Plain Base	X	X				X	X	X	X			X
.35 Win.	X	X	X	X								
Gas Check	X											
Plain Base	X	X	X	X		X	X	X	X	X		X
.33 Whelen				X								
Gas Check												
Plain Base												
.35 Win. Self Loading	X											
Gas Check	X											
Plain Base	X					X	X	X	X			X
.351 Win. Self Loading	X											
Gas Check	X											
Plain Base	X					X	X	X	X			X
.375 Magnum					X							
Gas Check												
Plain Base						X						
.38-40 (.38 W.C.F.)	X											
Gas Check	X											
Plain Base	X					X	X	X	X			X
.38-55			X									
Gas Check			X									
Plain Base						X	X	X	X	X	X	
.401 Win. S. L.	X											
Gas Check												
Plain Base						X	X	X	X			X
.405 Win.			X	X								
Gas Check												
Plain Base						X	X	X	X	X	X	X
.44-40 (.44 W.C.F.)	X											
Gas Check	X											
Plain Base						X	X	X	X	X		X
.45-70			X									
Gas Check			X									
Plain Base						X	X	X	X	X	X	
.45-90		X	X									
Gas Check												
Plain Base						X	X	X	X	X	X	
8 m/m Navy					X							
Gas Check												
Plain Base						X	X	X	X	X	X	

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	DuPont Powders						Hercules Powders					
	I.M.R. 4227	I.M.R. 4198	I.M.R. 3031	I.M.R. 4320	I.M.R. 4064	80	Unique	Sharpshooter	Lightning	HiVel No. 2	HiVel No. 3	2400
6.5 m/m Mannlicher			X		X					X		
Gas Check						X						
Plain Base						X						
7 m/m Mauser			X	X	X							
Gas Check						X	X	X	X	X	X	X
Plain Base						X	X	X	X	X	X	X
7.62 m/m Russian			X	X	X							
Gas Check						X	X	X	X	X	X	
Plain Base						X	X	X	X	X	X	
7.65 m/m Mauser			X	X	X							
Gas Check						X	X	X	X	X		
Plain Base						X	X	X	X	X		
8 m/m Mauser (7.9)			X	X	X							
Gas Check						X	X	X	X	X	X	
Plain Base						X	X	X	X	X	X	
8 m/m Mannlicher			X		X							
Gas Check												
Plain Base						X						

120 *duPont I.M.R. No. 17½.* This powder is comparable in its range of usefulness, to I.M.R. No. 3031 but, being an early nitro-cellulose powder, its tolerance is narrower than that of No. 3031. 17½ is difficult to ignite but is an excellent powder when ignited properly. It has been used with gas-check bullets with a fair degree of success but its normal burning pressure is too high for such bullets and its proper use is in full loads with jacketed bullets. The "½" means that metallic tin is incorporated in this powder.

duPont I.M.R. No. 15½. This is another "tin" powder, comparable to the new I.M.R. 4064 in its range of usefulness. It was brought out particularly for cartridges of small bore and large powder capacity such as the Newton and Magnum cartridges and is not as efficient as its newer counterpart in the military range of cartridges. Like 17½, it is hard to ignite but satisfactory if ignited properly and used in full charges with jacketed bullets, in the limited range of cartridges for which it was made. No more of this powder will be manufactured.

duPont I.M.R. No. 1147. This is another of the single base or straight nitro-cellulose powders. I.M.R. No. 1147 was made especially for the Cal. .30-06 cartridge using the 173 grain boat-tail bullet and it was a good powder as far as long range accuracy was concerned. The well known and justly famous 1925 National Match ammunition was loaded with this powder and that statement would be a tribute to any powder. 1147 is a fine grained powder and flows nicely through mechanical powder measures but, paradoxical as it may seem, the use of this powder was abandoned by the government because it would not measure through the loading machines with sufficient accuracy. The specifications for the Government ammunition call for a definite muzzle velocity within an equally definite limit of pressure. I.M.R. No. 1147 would develop the muzzle velocity alright but the pressures were so close to the permissible limit that even the little variations in loading it mechanically were enough to put them over the line. When we are
121 reloading ammunition and get evidence of high pressure, we correct it by reducing the powder charge a little. In other words, we change the specifications of the ammunition to suit the powder. But you can't do that with military

ammunition; the specifications stay fixed and if a powder doesn't meet them, the powder is changed and that is what happened to this otherwise excellent powder.

No. 1147, in comparison with the new range of duPont powders, occupies the position of, and has about the same application as, I.M.R. Powder No. 4320. While No. 1147 is now obsolete, powder tables are available for it.

I.M.R. Powders numbers 1204, 17½, 15½ and 1147 are all progressive burning powders and as their manufacture has only recently been discontinued all available stocks should be fresh and in good condition. Tables of charges are available for all of them, and while those reloaders who have their charges all established and who have been getting good results with them will want, quite naturally, to stick with them as long as they are obtainable, the beginner is urged to use the newer I.M.R., or other powders in their place. The powders given in the foregoing table are easier to ignite, burn more uniformly and will give better all-around results for reloading purposes.

I.M.R. No. 1185. This is a powder made especially for the Government for loading the Cal. .30 Model 1906 M1 cartridge with the 173 grain boat-tail bullet, for military usage. It is not obtainable commercially and can only be bought by members of the National Rifle Association, through the Director of Civilian Marksmanship. No more of it is being manufactured and no more will be obtainable when present stocks are exhausted. I.M.R. 1185 can, probably, be used in some other cartridges than the Cal. .30-06 but no such loading data is available for it. It is not suitable for reduced loads and its use is best confined to the Cal. .30-06 cartridge, using the 173 grain boat-tail service bullet with the proper weight of charge. Frankford Arsenal furnishes proper loading data for the .30-06 M1 cartridge.

Pyro Cal. .30 d. g. This was the first successful 122
military powder developed for the Cal. .30, Model 1906 cartridge, which used a 150 grain, flat base, jacketed bullet. It is a plain burning military smokeless powder and was for many years the only military rifle powder used by the United States. Its name indicates its composition, the "Pyro" standing for pyro-cellulose, which is a nitro-cotton of low nitrogen content—(12.6%). The "Cal. .30", indicates the caliber it was made for and the "d", that diphenylamine was used as a stabilizer. The "g" indicates that the powder contains graphite. This powder was also sold commercially for reloading purposes and could be used in a variety of cartridges. The commercial powders were known as duPont No. 20, and Hercules No. 308 powders. The Pyro Powders had a rather narrow tolerance and could not and should not be used for reduced loads, nor with cast bullets.

Pyro Cal. .30 d.g., was used in loading all war-time ammunition in .30-06 caliber up until the completion of the Government war contracts. Much of this powder was of poor quality because of hasty manufacture and the inability to get ingredients of the proper degree of purity and a lot of it, as well as ammunition loaded with it, has gone bad in storage. But it was by no means all bad and there is still some of it around that is in serviceable condition. Any of this powder that may have been purchased from the Director of Civilian Marksmanship within a reasonable period of time may be relied upon and can be loaded according to the data furnished by the shipping arsenal.

If the powder has been obtained from unknown sources or has been on hand for a considerable length of time, the reloader is advised to reduce his charges at least 5% from the standard, or better still, not to use the powder at all. This also applies to old canisters of duPont No. 20 and Hercules No. 308 powders. More or less of the volatiles will have evaporated from this powder, if it is old, creating a corresponding increase in ballistics. This will cause irregular burning and more rapid burning than normal
123 and, if old powder is used in heavy charges, dangerous pressures are likely to result. There is no sense in fooling around with odd lots and old "clucks" of powders when fresh stocks of modern, progressive powders are readily available. The purchase of such lots of Government powder as may be offered for sale from time to time is only justifiable if you are content to load it in the cartridge it was made for and exactly according to the loading data furnished with it. On the other hand, if you want a powder for general reloading purposes, and especially in other than U. S. Military cartridges, get a powder that is made for the purpose and on which adequate loading information is available. The few cents a pound that you save on the Government powder is no economy if you can't use the powder after you get it, and it costs just as much to *ship* one kind of powder as another.

Shotgun Powders. The ballistic requirements of powders for shotguns are entirely different from those for rifled arms. It is important that when a shot charge leaves the muzzle of the gun there should be relatively little pressure behind it, for if the muzzle pressure be too great, blown patterns will result. A blown pattern is caused by the filler wads driving through the shot charge, scattering the shot laterally and causing a pattern in the form of a ring of scattered shot with few or no shot in the center. To prevent this condition, quick burning powders are necessary and to make these powders burn fast, potassium or barium nitrate are sometimes incorporated in them. Shotgun powders are of two general classes; bulk powders and dense powders. The latter are manufactured in much the same manner as rifle and pistol powders and are usually cut into thin flakes or discs to increase their rate of burning. The bulk powders are made by a precipitation process and the grains take the form of small irregularly shaped lumps, porous and soft in nature and gelatinized only on their surfaces. Most of the dense shotgun powders are absolutely unsuited for use in rifle or pistol cartridges. Even
124 in reduced loads, they will give relatively high pressures for the low velocities they develop.

The bulk powders, of which there are two manufactured in the United States, are known as duPont Shotgun Smokeless and Hercules E. C. These powders can not be recommended for use in rifled arms but they can be used in reduced loads in some cartridges with good results. Due to their rapid burning and porous nature, they will develop dangerous pressures if overloaded and as no loading data is regularly available for using them in rifled arms, their use for such purposes should be avoided. The mere fact

that a powder *can* be used is no excuse for using it, when safer and more efficient powders are available.

Blank Cartridge Powder. This is a type of powder made especially for blank cartridges. It is extremely fast burning and develops high pressures even in blank cartridges. Loaded behind a bullet, it will almost surely burst any ordinary arm. This powder is not available to reloaders but in spite of this some of it turns up once in a blue moon. If, by any remote chance any of it comes into your possession, destroy it at once. It is not only highly dangerous, but absolutely worthless for reloading purposes. Do not take any chances with it.

Old Powders

Sometimes old cans of powder will turn up and come into one's possession, usually as a gift from someone who used to reload ammunition years before. Such powder may be in good condition but the chances are against it, even though it appears to perform satisfactorily. There is no reason why it should not be used, but it is best to use it in reduced loads for short range shooting. I have some old Laflin & Rand powders that are still very good but I have some others that are not. The double base or nitro-glycerine powders will keep better and longer than nitro-cellulose or single base powders and one should be especially careful when using old lots of the latter type.

Where To Obtain Powder.

125 Up until about a year ago, powder could only be shipped by freight. There were very severe restrictions and regulations on the way the powder had to be packed and the freight car it went into had to be labeled that it had explosives in it, etc., etc. The freight rate was one and a half times the first class rate and it was necessary to pay freight on one hundred pounds, even though the shipment only consisted of one lousy little canister of powder. Naturally, the freight charges were greatly in excess of the value of the powder, when shipped in small quantities, and it was a pretty tough and expensive job for a reloader to get powder. Thanks largely, and possibly entirely, to Belding & Mull, the Interstate Commerce Commission was finally convinced that smokeless powder was not as dangerous to transport as had been believed, and the shipping regulations have now been changed. SMOKELESS AND SEMI-SMOKELESS powders may now be shipped by express, at regular rates, the only restriction being that not more than ten canisters, containing not more than one pound of powder each, can be shipped in one case. BLACK POWDER MUST STILL BE SHIPPED BY FREIGHT. The change in regulations on the shipment of smokeless powder now makes it possible for the handloader to get about any kind of smokeless he wants, at a reasonable shipping cost.

It is advisable for the reloader to purchase his powder as close to home as he can so as to save as much as possible on the shipping charges. E. I. duPont de Nemours & Co., and The Hercules Powder Co., both of Wilmington, Delaware, are the only two manufacturers of smokeless powders in the country. They also manufacture black powder. Both companies have distributing points in various parts of the country, so by writing them, one can determine the most convenient point from which to order powder. Most, if not all, of the reloading tool manufacturers also carry stocks of powder. The Lyman Gun Sight Corp.,
126 endeavors to maintain an up-to-date list of dealers throughout the country who carry stocks of powders and cater to the needs of the handloader and it is entirely possible that other manufacturers of loading tools do likewise. The reader will do well, when in need of powder, to communicate with one or all of the firms mentioned, but first (and this may sound silly) inquire of your local sporting goods dealers, if any. I have on many occasions received requests for sources of supply for powders from localities where powder was readily available.

Semi-smokeless powder can be obtained from the King Powder Co., King's Mills, Ohio. As far as I know, this firm has no other distributing point but some dealers carry semi-smokeless in stock. In writing for sources of supply, be sure to give the name of the nearest large city, if you live in a small community, as dealers in small towns seldom find it worth while to carry powder in stock or to handle it at all.

The Care and Storage of Powder

The saltpeter, sulphur and charcoal from which black powder is made are all capable of absorbing considerable quantities of atmospheric moisture and combining them into powder does not reduce their absorbent qualities. The graphite with which black powder grains are often coated helps to exclude moisture but does not absolutely prevent its absorption. Black powder is completely ruined by water and even though it only becomes damp, it will not regain its original strength when it dries out. Moisture causes some of the saltpeter to dissolve and this saltpeter crystallizes out when the powder dries, destroying the original intimate mixture of the ingredients. The old adage, "keep your powder dry," is well applied to the storage of black powder. It must be kept dry, but the temperature under which it is stored is not important, so long as it does not approach the combustion point of the powder, of course. This point is way above the temperature of the hottest attic in summer so it is safe to say that the handloader can keep his black
127 powder in any dry place away from fire. Black powder is a mechanical mixture and contains no solvents or volatiles that affect its burning rate.

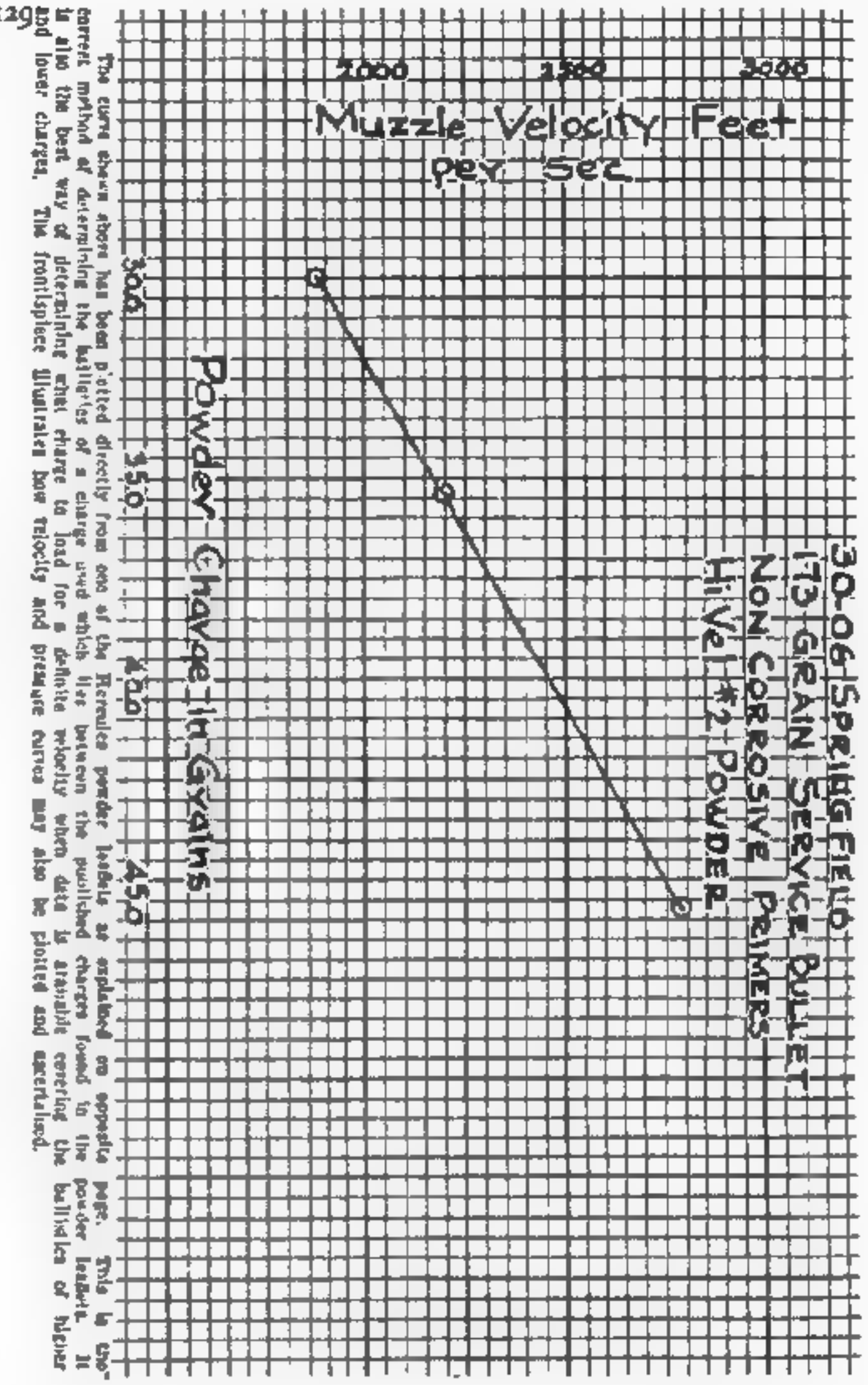
Smokeless powder presents a set of conditions almost the reverse of those affecting the storage of black powder. In the first place, smokeless powder is not affected by moisture. Of course it can not be fired when wet, but wetting it and drying it out does not affect its ballistic properties. In fact, one of the best ways to store smokeless powder for long periods of time is to immerse it in water. This method of storing powder is fairly new and was discovered quite by accident. A sunken French battle ship was raised after many years, during which the magazines had been full of salt water. Powder from these magazines, when dried out and tested, was found to give practically the same ballistics as when the powder was made many years before. This instance has led to the under-water storage of military powders, the use of which may not be required for years.

It has already been pointed out that in making smokeless powders, all of the solvents and volatiles can not be recovered from them and that the percentage of volatiles in them has a direct bearing upon the performance of the powder. Heat will drive these volatiles out rapidly, leaving the grains porous and greatly accelerating the rate of burning. Storage under water keeps the temperature of the powder down and prevents it from drying out. Where powder must be kept in readiness for instant use, underwater storage is out of the question. Ordinarily, such powder is kept in hermetically sealed containers which are stored in easily accessible magazines. These magazines are well ventilated and sometimes are provided with means for keeping the temperature at an even level. 70° F. is considered about ideal and most ballistic tests are made with the powder at this temperature, but smokeless powder will stand very low temperatures. It will not remain stable at high temperatures and the reloader should keep his smokeless powders where the temperature never exceeds 90° F.; preferably, but not necessarily, in a dry place. The choice between a hot dry attic and a damp cool cellar should be the damp cellar for smokeless powder, and the hot attic for black powder. If the powder must be kept in a damp place, small gaskets of cork or rubber should be made for the canisters and the lids screwed firmly down against them.

But after all, why worry about hot attics or damp cellars? Our American powders are remarkably stable and if kept in a room where the temperature is livable they will keep almost indefinitely.

Determination of Charges by Interpolation.

The powder companies' tables can be used to verify charges obtained from other sources, just as the spelling of a word may be verified from a dictionary. The usefulness of these tables is by no means limited to the simple procedure of picking a charge out from among those listed. As most of these tables give more than one charge for each weight of bullet for each caliber, and the difference between such loads is represented only by the difference in the weights of powder charges, a fairly accurate charge and velocity curve can be plotted from them. To do this, the vertical edge of a sheet of cross-section paper is marked off in increments of velocity in feet per second, within the limits of the loads in the table; then the horizontal side of the squares in increments of weights of charge, also within the limits of charges shown in the table. Dots can then be placed on the intersections of the horizontal and vertical lines, representing the charge and velocity for each load, and connected by straight lines. If only two points are used, the "curve" will be a straight line and more than two points will give an angular line but this can be smoothed out into a regular curve beginning at the lowest point and terminating at the highest one, passing through any intermediate points. One can then read off the velocity of any charge of that powder for the cartridge and bullet it pertains to and the velocity figure obtained in this way will be quite accurate. It is useless to do this with loads taken from several different tables; they must all be from the same table and for the same caliber of cartridge and weight of bullet, if only the bullet weight is given, or for the same make, weight and kind of bullet if possible. Every condition must be exactly the same, except the weights of the charges.



Extending the curve beyond the plotted points will not give accurate results and it is of little use to do this, as the highest charge given in the table is probably the heaviest one that should be loaded anyway.

This can also be done with pressures, making the curve a charge and pressure one, but there is absolutely no reason for making such a curve. As long as the pressure is safe, who cares what it is? IF A CHARGE AND PRESSURE CURVE IS PLOTTED FROM A POWDER TABLE, UNDER NO CIRCUMSTANCES SHOULD THE CURVE BE EXTENDED BEYOND THE HIGHEST CHARGE POINT. NO ONE CAN PREDICT WHAT WILL HAPPEN BEYOND THIS POINT. The heaviest loads in the tables should only be used with the greatest care and with new cases. Even new cases are not infallible, for once in a while they will give way near the heads because of some hidden defect that could not be seen by the inspectors. The illustration on Plate XVI shows two failures of this kind that occurred with normal factory loaded

ammunition. Both were fired in bolt action rifles and both resulted in eye burns from the gas escaping back through the bolts. If you *must* load the heaviest permissible charges into your cartridges, by all means use new cases and answer the following questions to yourself before going ahead with the loading.

1. Are my bullets of the same diameter, weight and hardness as those used in establishing the load?
2. Are the bore and groove dimensions and the throating of my gun the same as those of the test gun?
3. Do I know the correct depth to which the bullets should be seated?
4. Are my cases of the same inside shape and the same 131
capacity as those used in developing the load?
5. Are the vents of my cases the same diameter as those of the cases with which the load was developed?
6. Are my primers correct for the vent size of my cases and will they give the same order of ignition as those used by the powder manufacturer?
7. Is the chambering of my barrel the same as that of the test barrel and especially, is it the same diameter at the neck?
8. Is my gun breeched up properly and in safe condition to use with heavy loads?

If you can answer all of those questions in the affirmative you can, by careful loading, duplicate the ballistics of the load in the table of charges. I might even say that if you can answer all of those questions in the affirmative, you are a magician. The sole point in listing them is to show that duplicating the results shown in a table of charges takes a lot more than just using the same kind of a bullet and being careful with the weights of the powder charges. It is best to keep the weights of charges just a little less than those shown in the tables when the heaviest loads are used, for a little shading in the charge will not cause much loss of velocity but it will ease up the pressures and allow for the variables in components that the reloader has no means of detecting.

Variations in Components.

The variations in components that will cause increases in pressure may be summarized as follows:

1. Enlarged vent in the cartridge case permitting more of the primer flash to reach the charge thereby increasing the initial rate of burning. This will also increase the back thrust of the primer itself, due to higher pressure than normal within the primer pocket.
2. The use of a hotter primer than the vent is designed for will also increase the initial rate of burning of the charge.
3. The use of too much of the right kind of powder. 132
The increase in the total burning area and decrease in the air space will cause the pressure to accelerate more rapidly than normal and to reach a higher point before the bullet has had time to move forward.
4. The use of too fine or too fast burning powder in heavy charges. This refers particularly to powders for pistols or small rifle cartridges when used in the larger rifle cartridges. Such powders are useful in reduced loads but if charges are increased too much, the pressures will develop so rapidly that they will practically cause all of the powder to burn at once. A slight over-load of these powders is far more dangerous than with the coarser grained and slower burning powders.
5. The use of a heavier bullet than normal. The heavier the bullet, the greater the time and force required to overcome its inertia.
6. A larger bullet than normal. An increase in the bullet diameter will increase the force and time necessary to impress it into the rifling and will also increase the friction between it and the barrel.
7. A harder bullet will increase pressures for the reasons already mentioned. However, the variations in hardness of factory jacketed bullets can be ignored with all normal loads. In revolvers, soft bullets are more dangerous than hard ones with heavy loads, as soft bullets up-set greatly between barrels and cylinders.
8. A longer bullet than normal will cause some increase in pressure because of the greater bearing surface but this condition does not have any effect until *after* the bullet has started forward. As an increase in length would of necessity be accompanied by an increase in weight also, the condition in paragraph 5 would apply.

Another factor of importance in connection with the
133 use of heavy loads is the arm itself. I refer now to the type of arm. It must be borne in mind that when one is shooting a bolt action rifle, the shooter's face is somewhat removed from the head of the cartridge. If a break occurs in the head of a case or a primer is pierced, the escaping gas must pass back through or around the bolt, where there are various mechanical parts to help impede and deflect it. This is not true of most single shot rifles. When shooting these arms the shooter's face is right up on top of the cartridge and when something does let go, it is likely to be just too bad. Bushed firing pins or other trick alterations of the firing mechanism may be of some use in supporting the normal thrust of the cartridge case and primer, but when the case gives way these gadgets are just so many more pieces to fly around.

Revolvers and pistols are not so bad when they blow up, as they are held well away from the face of the firer. Fortunately, the force of explosion and the direction of the flying pieces is lateral and upward for the most part. Pieces seldom come to the rear, although they can, and the most that a shooter is likely to lose is a finger or two off his gun hand, which isn't so bad as he will still have six left. But eyes are different; we only have one of these to spare and it seems a pity that handloaders should risk them by following the guff and ballyhoo of the barnyard ballisticians, who, like children in a sand box, fill cartridge cases up with powder, get away with it by the grace of God, and then loudly proclaim to the world that the ballistic engineers of the powder companies don't know what they're talking about.

The illlustration on Plate XI shows the top of a cylinder of a revolver, blown up with overloaded, reloaded ammunition. Whether the owner just didn't know what he was doing or whether he was following some information re-

ceived from unreliable sources, I don't know, but he sure did a good job. Note that the "blow" was not caused by one overloaded cartridge. The gas pressure, or the set-back from the cartridge fired, fired the cartridges on either side 134
of it. Had the cartridges in the chambers on either side of the one fired in the usual manner, been normal loads, it is unlikely that the top would have been completely lifted off the cylinder. Even if it had been, there would have been no expansion of the side chambers, but you can see that both of these chambers are expanded from the overloads that they contained.

If you must fool around with these crazy loads, be philosophical about it if you get injured or maimed. Charge the damage off to experience, get a new gun, and use better judgment in the future.

• • •

I am closing this chapter on powders with the expressed hope that no reader feels disappointed because there has not been included several yards of printed tabulations showing all the "recommended" charges for the various cartridges with all the smokeless powders dating back to the time of the Spanish-American War. I could have copied these off from various sources, but decided not to. Instead, let me again urge the reader to write the powder manufacturers and get from them the latest descriptive folders giving a list of charges for the cartridges he is interested in. Then obtain a supply of cross-section paper, ruled in tenths of an inch, in order to be able to plot down and interpolate any number of *safe* loads from the charges given in these folders; using the method described on page 128 and illustrated on page 129.

I have the most profound respect for these little duPont and Hercules powder folders. The information in them is authentic and accurate, they tell so many stories, when carefully analyzed, that their usefulness goes far beyond the superficiality of a list of charges which can be lifted out, body and breeches, and loaded into cartridges. Within their limits, they offer the handloader all the facilities of a ballistic laboratory, without the fuss, bother and expense of doing the work.

Chapter Four 135

BULLETS.

The first missiles fired from arms using gun powder as a propellant were probably stone and we do know that cast iron balls were used in the early history of such arms, but as neither of these substances are of any use to us for reloading ammunition we can jump forward to the use of lead or alloys of this metal.

Smooth bore, muzzle loading muskets used lead balls—that is—the projectiles were approximately spheres or balls before they were loaded. These arms were notoriously inaccurate, because the "balls" had to be smaller than the bore in order to load them and when fired, bore harder on one side of the barrel than the other, causing them to take a flight like a pitcher's curved ball. As their direction of rotation was a matter of chance, both as to degree and direction, the shooting was erratic. Difficulty was encoun-
tered in making these balls stay down on the powder charge. The "Brown Bess" was the standard arm of the British forces during the American Revolution, and each British soldier was issued an iron mallet which was used to hammer the end of the ramrod and upset the ball enough to keep it in place. This upsetting, or flattening of the ball, may have reduced its tendency to roll, but it made it scale instead. Fifty yards was about the greatest distance at which a mark the size of a man could be hit with any 136
certainty with these smooth bore muskets. This led to the adoption of a range finding system in battle that consisted of holding the fire until the whites of the enemy's eyes could be seen. For average eyes this distance is just about fifty yards.

The idea of using spiral grooves, or rifling, in a barrel to impart rotation to a bullet and keep it stable in flight, is lost in antiquity. The difficulty in doing this was that the bullet had to be small enough to be pushed down the bore and still be large enough to fill the grooves after it got there. This difficulty was overcome by some unsung colonial gunsmith or rifleman by using a ball smaller than the bore, covered with a patch of sufficient thickness to fill the grooves, the soft patch being compressed into the grooves as the ball was forced down the bore. When the arm was fired, the patch followed the rifling, imparting rotation to the ball but left the ball on passing out of the muzzle. The ball, undeformed, continued to rotate as it sped on its way. This condition could be duplicated with each shot and the improvement in accuracy over the old smooth bores was remarkable. Some of these old muzzle loading rifles could, and still can, show a degree of accuracy, within the limits of their effective range, that can be exceeded only by the very best of our modern rifles. The popular belief that all of the old muzzle loading rifles were extremely accurate is fallacious. Much depended upon the rifle and much more upon the shooter. There were undoubtably "gun bugs" in the days of the muzzle loaders' just as there are today, and it is but natural that those who studied their arms and the loading of them, and sought the products of the best gunsmiths, should get the best results.

Buckskin and linen were the two materials used for patches, because they were the only suitable materials avail- 137
able at the time, but today a variety of cotton fabrics can be used with excellent results.

When breech loaders came into use, the need for a patched bullet or ball was no longer necessary, as it was then possible to use a bullet large enough to fill the grooves of the rifling, inasmuch as the bullet was seated behind the rifling, instead of being forced down the bore from the muzzle. As a naked and unlubricated lead bullet will quickly lead a barrel and render it inaccurate, bullets were provided with grooves, or cannelures, which were filled with lubricant. But the use of patches did not disappear for a long time, although their form changed from those used in the old Kentucky rifles, nor did muzzle loading cease to be practiced.

Patched Bullets

Paper patched bullets were in quite common use when the writer began his shooting career and could be purchased from any of the ammunition companies for reload-

ing purposes. These bullets were either loaded into the cases and used just as our present day ammunition is used, or they were seated into the barrel the proper distance with a bullet seater, after which the case, charged with powder, was put into the chamber behind them. Many records were made with arms loaded in this way and today many of the old Schutzen rifles are being resurrected, with surprising results to some of the boys to whom the smell of black powder is a novelty.

Because of this resurrection and the difficulty of finding information on methods of patching bullets, a description of the procedure is given here. Be it understood that the writer never put a paper patch on a bullet in his life and that the following comments are taken from the experience of honorable and straight shooting gentlemen who did do it and knew how.

Paper-patching Bullets. "Bullets to be patched with paper are smooth, without grooves. They are from three to six thousandths of an inch smaller than the standard size. The diameter is increased to the size desired by having a thin paper patch rolled around them, covering about two thirds of the bullet from the base up. The paper should be of fine, strong texture, similar to bank note paper. (Note: When paper patched bullets were popular, a special grade 138
of paper was made for patching them and came in four thicknesses; extra thin, thin, medium, and thick. The extra thin was about .0015 thick and there was an increase of about a half thousandth of an inch in each succeeding size.) Shooters wishing to increase or decrease the diameter of their bullets can do so by using the proper thickness of paper. There is a difference of opinion relative to the advantage or superiority of patched bullets over grooved, yet for hunting or military purposes the grooved ball is generally preferred, as such ammunition can be carried and exposed to wet weather without injury; while a part of the patch being exposed is Lable to get wet and injured so as to impair its accuracy. Still, for fine target-shooting, the patched bullet properly handled is, without doubt, preferable.

The ordinary factory patched bullets have *two* laps of paper around them. The patch is cut in length so that the ends do not lap over but almost butt up to each other. The regular patch is cut on an angle of about 35 or 40 degrees, as shown in the cut. This angle is so that the joining of the laps will not be parallel with the rifling or the axis of the bullet, thus holding the patch over both points of the lap.

How to Fit Patch. First cut a strip of paper the width desired; have it long enough to lap *three* times; roll firmly about the body of the bullet; have edge of paper even with base of bullet; when so rolled, hold point of bullet from you and with the point of a sharp knife cut through all the thicknesses of paper *except* about a sixteenth of an inch at the base; commence cutting from the point toward the base, scribing the angle desired around the circumference of the bullet. When unrolled the *two inner full-sized pieces* that are held together by the uncut part will represent, *when put together*, the shape and length of patch desired, except the cutting off of about one sixty-fourth of an inch in length, preserving the same angle, thus 139
preventing the possibility of the ends lapping over. When the patch is found to be correct, a piece of sheet metal can be filed up to the shape and size, to be used as a template or pattern to cut others.

Before putting the patches on, it will be well to dampen them between two wet cloths, so as to take the crisp out

Method of Rolling Patch.

of the paper. This will also cause it to lay snugly to the ball and help in the matter of closing the paper over the base, which when perfectly dried will have shrunk firmly to the bullet. *Do not* make patches too wet, or use mucilage or any sticky substance, for patches *must leave the bullet clean* at departure from the rifle.

How to Roll Patch. Lay the patch on a smooth board or table with the point of one of the angles toward you and to your *right*; let the whole of the angle project over the edge of the board or table (this will leave the point of the patch free, not stuck down to the table); then place the bullet squarely on the patch (base to the left), letting as much of the paper project beyond the base as 140
you desire. When the bullet is in position, turn the projecting point of the patch up over the bullet and, with a forward push, roll the bullet up on the patch. If the patch is not rolling on straight, roll the bullet back, readjust it, and try again. With a little practice this can be done accurately every time.

Paper patched factory bullets used to be made with a hollow in the bases. With such bullets, the patch should project beyond the base of the bullet about two thirds of the bullet diameter. This projecting paper is twisted up and pressed into the base cavity.

With flat base bullets, allow the patch to project only *one third* of the diameter of the bullet, turn the paper in over the base of the bullet and press the base of the bullet on the table. This will leave the center of the base of the bullet bare.

The Chase Patch. This is a square end patch, wrapped only once around the bullet with the ends just butting together. The patch is wrapped around the bullet with its edge just flush with the base of the bullet, the patch lapping only once around the bullet. The patch is inserted in the Schutzen bullet seater, it should project beyond the mouth of the case that forms part of the bullet seater. It may

be squared up by pressing gently against the plunger of the bullet seater so as to form a cylindrical tube. Insert the bullet inside of the patch so that both the rear of the patch and the base of the bullet are against the plunger; patch and bullet are seated in the barrel ahead of the case to the desired depth. This method of patching is impractical except for fine target shooting but it has made some of the best records ever obtained. Dry, crisp paper is used for making the Chase Patch.

In seating regular patched bullets in the shell (in the ordinary manner) some shooters used to use a thin wad over the powder, then a disc of lubricant on top of the wad with the bullet on top. Others seated the bullet on top of the powder without wad or lubricant, wiping the bore out after each shot. Experience must decide these points 141
for each shooter." (The body of the foregoing, if not the breeches, has with some modifications, been taken from an old Ideal Hand Book.)

For the benefit of the younger generation, a Schutzen bullet seater is a device for seating bullets in the barrels of rifles, independently of the cartridge case. It takes the form of a cartridge case of the same caliber as the rifle, with a sliding plunger inside actuated by an extended handle, usually off-set for convenience. The travel of the plunger may be definitely fixed or may be adjustable to provide seating the bullets in the barrel to any desired depth. The bullet is inserted in the mouth of the case, the case inserted in the chamber, and the plunger forced forward to the limit of its stop. The case, charged with powder, was inserted after the bullet was seated. This is essentially the same method that is employed in loading large caliber cannon today, as is described elsewhere in this book.

Cast Bullets.

There are two methods of making lead or lead alloy bullets; one is to cast them in moulds and the other is to swage them to shape. The latter method is used in making factory bullets, it makes a bullet of more uniform shape and density than can be made by casting. A slug is first cast in a mould or is cut from lead wire of a suitable size. These slugs are rammed into a die having the profile of the bullet, but without grooves, under heavy pressure. The slugs are of a greater volume than the die into which they are forced and the excess metal is squeezed out through a small hole in the side of the die, in the form of a fine wire known as "weep". This insures full and uniform bullets. The slugs or cores of jacketed and soft point bullets are made in the same way. After the bullets come from the die they are rumbled to remove the oil, as well as any burrs from them, after which the grooves are rolled into them and they are sized to the correct diameter.

The method of casting bullets has been described elsewhere but as this type of bullet is the one that the reloader 142
depends on for economical shooting and is used extensively, some space will be devoted here to a few side lights on it. Cast bullets are of three general types; flat base, hollow base, and gas-check base.

Flat Base Bullets. The flat base bullet, as its name implies, has a flat base that is the full diameter of the bullet. Moulds for this type of bullet are made so that the cut-off is at the base of the bullet and it is necessary that the cut-off screw be tight and that the cut-off fits flat on the top surface of the mould to cast these bullets correctly. When black powder was the only powder available, bullets were often made smaller than the groove diameters of the barrels they were used in and the expansion of the base under the sudden thrust of the powder gasses was depended upon to fill the rifling. Many of the old black powder arms had rifling grooves much deeper than are found in modern arms and some would not accommodate cartridges loaded with bullets that were the full groove diameter. This condition is seldom found in present day arms, the noteworthy exceptions being the .256 Newton, 6.5 Mauser and Mannlicher and some 8 m/m Mausers.

Some plain base bullets were also made with a bevel on the edge of the base. In the deep rifling of the older arms, fins were pushed back over the edge of the bullet base as it was impressed into the rifling and these fins were detrimental to the best of accuracy. The bevel on the base of the bullet prevented this occurence but unless the bevel was perfect, no advantage was gained by it. As most modern rifles are made for jacketed bullets, the grooves are relatively shallow. Such slight fins as may be formed on bullets with square, sharp bases are probably blown off by the muzzle blast. At least, this factor is no longer considered of consequence. If a flat base bullet is very much larger than the groove diameter of the barrel it is fired in, metal must be pushed back all around the entire base of the bullet and this doesn't help the accuracy any.

143 ***Hollow Base Bullets.*** Moulds for hollow base bullets are made to cast the bullets with the points, or rather the noses toward the cut-off and for this reason must have flat noses. It is impossible to make a mould to cast a pointed bullet with a hollow base. Hollow base bullets are only used in revolvers and, except for deep seating bullets, there is neither excuse nor reason for such bullets in modern revolvers. Early revolver cartridges used bullets that were the same diameter as the cartridge case, having heels on the rear ends that fitted tightly inside of the cases. They were crimped by a rolling operation, which can not be duplicated in a handloading tool. These bullets were lubricated on the outside by dipping the bullets into melted lubricant after the cartridges were loaded. Most rim-fire cartridges are still made in this way. The outside lubrication was messy and picked up dirt and grit, furthermore, the heels on the bullet bases did not expand or upset uniformly and the accuracy that could be obtained from outside lubricated cartridges was, at best, limited; the tales in dime novels notwithstanding. To overcome the objections of the outside lubricated bullet, grooves were made in the body of the bullet and the bullet was made small enough to fit *inside* of the case to a depth that would permit the lubrication grooves to be completely covered. This meant an increase in the length of the cartridge case and a very considerable reduction in the bullet diameter; a reduction so great that inside lubricated bullets will drop right through the barrels of revolvers made to shoot the outside lubricated bullet. Something had to be done to make the smaller bullets take the rifling, so deep concavities were put

in the bullet bases to facilitate their expansion.

About the only revolvers in common use today that were made for outside lubricated bullets, are the old Colt and Smith & Wesson Model 1901 army revolvers that were sold by the Director of Civilian Marksmanship a few years ago for $5.50 each. Thousands of these guns are in the hands of shooters. They were made to use the old .38 Long, outside lubricated cartridge and the chambers are practically 144
straight reamed holes. Cartridge cases are no longer obtainable and those for the .38 Long I.L. cartridge will not take the old heel bullets. They will take them, but will not hold them. The barrels are entirely too large for plain base, inside lubricated bullets. Hollow base conical bullets are no good in them with smokeless powder and not much good with black powder. I have fooled around with these old clucks off and on for a good many years but, until quite recently, I never did get one to shoot well enough to bother loading the ammunition for it. One day about a year ago, I received a letter from some fellow who had a model 1901 revolver. It was the only gun he had and I judged from his letter that there wasn't much chance of his getting another, so I didn't have the heart to advise him to hang it up over the mantle as a relic. He wanted a wad-cutter load for it which gave me an idea so I cast up some of Ed. McGivern's bullet (Ideal No. 358395) of a soft alloy and loaded them pretty well out of the cases with all the FFg black powder I could get behind them. The combination of the long, cylindrical bullet with the easily expanded hollow base did the trick and the load shot very well; far better than any other load I have ever used in this gun.

Hollow base bullets should not be used in revolvers with heavy loads. If fired from a revolver with the barrel removed, the hollow base will be literally turned inside out if the bullet is soft, and if it is hard, the base portion will be blown off entirely. Incidentally, the threaded part of the frame, where the barrel is screwed in, will be so nicely leaded that, in the absence of a thread chaser to clean the lead out of the threads, the gun will probably have to go back to the factory before the barrel can be replaced.

Fired in a normal gun, the hollow base will expand between the barrel and cylinder and in the beveled rear portion of the barrel. This results in a check in its free forward movement, similar to encountering an obstruction, and causes the pressure to rise excessively. With normal loads, this rise in pressure is not enough to cause any harm 145
but with heavy loads, such as are sometimes mentioned in magazine articles (but are never recommended by the companies that make the powders) a hollow base bullet may well cause pressures to rise to a point that will strain or burst the gun. In speaking of hollow base bullets I refer to these gosh-awful monstrosities with a hollow that one can hide in. If the concavity is merely a shallow depression of but a few hundredths of an inch deep, such as are found in *some* factory bullets, they will do no particular harm.

Gas-Check Bullets. These bullets have a heel on their bases over which shallow gilding metal cups or gas checks fit. They may be fired with heavier charges of powder than plain base bullets, the gas checks acting as a protection against the extra heat and pressure of such loads. Gas check bullets can also be used with some powders that are not suited to plain base bullets of the same caliber. This permits them to be fired at higher velocities than plain base bullets.

The question is often brought up as to how fast a gas check bullet may be driven with good accuracy and without fusing. (Stripping or fusion of the bullet does not occur until the bullet fuses or melts on the outside, from the heat of the gasses forcing past it.) The Ideal Hand Book has long published the figure of 1800 f.s. as the maximum velocity for gas check bullets but this, while a fair average for all such bullets and a velocity at which good accuracy can be obtained almost with certainty, is conservative in many instances. Good accuracy has been obtained with some bullets of this type at as high as 2400 fs., without leading the barrel but others will cause difficulties at much lower velocities. There just is no fixed rule and the reloader who wishes to get the highest velocity possible with a gas check bullet will have to do some experimenting. One shot will not tell anything and to find such a load with a minimum of shooting, the rifle should first be fired sufficiently
146 to foul the barrel and clean out all traces of oil. Next load and fire three cartridges, using a load that is fairly conservative to begin with and shoot for accuracy on a target. If the three shots group well, the charge in the next three cartridges can be increased. After each series of shots examine the barrel carefully for signs of leading, particularly near the muzzle. This may be seen as lumpy patches or streaks in the early stages, but with excessively heavy loads, the lead may cover the entire bore evenly and not be seen at all, except by the practiced eye. In this case there will be a splash of lead all around the muzzle. When the load is worked up to a point where leading occurs, the accuracy will probably go to the devil and an enlargement of the groups will usually occur before this point is reached. Keep a memorandum of the loads tried and when it appears that the accuracy is decreasing, stop.

The work thus far has been a crude approximation and before going further it will be necessary to clean the gun. If there are no visible signs of leading, scrubbing the bore out with a brass brush and nitro solvent will be sufficient. If leading is present, scrub the bore with a *dry* brass brush. If the brush has previously had oil or nitro solvent on it, wash it in gasoline or carbon tetrachloride before using it. Then plug the chamber with a *tight* fitting cork or wooden plug, fill the bore with metallic mercury and let it stand for a couple of hours; pour the mercury out and wipe the bore clean with a *dry* patch and examine it for signs of lead. If the lead is not all out, repeat the process. The word "dry" is emphasized because even a slight trace of oil on the leaded surface will prevent the mercury from picking the lead up. I know of nothing besides metallic mercury that will thoroughly remove a good dose of lead from a barrel and if the lead is not *all* removed, it will quickly pick up more lead when the gun is fired again. Also be sure that the cork is driven into the chamber tightly, for mercury is heavy and when poured down a barrel it lands on the cork with a severe jolt. If the cork comes out, you

will have a mess on your hands. Mercury can be obtained 147
from any wholesale drug or dental supply house in small, one pound jugs and it is handy stuff to have around if one uses lead bullets. It will also take out the fouling of metal jacketed bullets and can be saved and used over and over again.

When the barrel is clean, select the heaviest load that gave good apparent accuracy with three shots and load up twenty cartridges, firing them for accuracy. If the accuracy holds up for twenty shots and does not show more than slight traces of leading, you probably have the heaviest load that can be fired satisfactorily *in your rifle*. It does not necessarily hold that the same load will be good in another rifle of the same caliber. The alloy used, the individual mould, the bullet size, the lubricant used, the bore and groove dimensions of the barrel and the throating all enter into this as well as the kind of powder, which makes it impossible to lay down any fixed limit of velocity for any bullet and arm. Sure, it's a lot of work, but the fellow who wants the last fraction of an inch of muzzle velocity with a cast bullet can't expect to get it by sitting in a rocking chair and reading a book.

A question that is often asked about gas check bullets is: Can they be used without the gas checks and with good accuracy? The answer to this, like the answer to most questions regarding the loading or reloading of ammunition, is yes and no. A gas check bullet has a heel on the base to which the gas check is fitted and this heel is considerably smaller than the bearing surface of the bullet. Used without the gas checks, the true or effective base of the bullet becomes the exposed surface of the first band and the heel becomes a nuisance, for if the heel upsets irregularly, the muzzle blast, impinging on it after the bullet has left the muzzle of the barrel, will cause some deflection. The difference between the diameter of the heel and that of the bearing surface of the bullet is too great to expect the heel to expand to the groove diameter of the barrel with any charge of powder that can properly be used with a plain 148
base bullet. The heel is stubby and the gasses act around the outside of it as well as against the rear and while no definite rule can be given, it is best to use a fairly hard alloy for casting the bullets, then they will usually give excellent results with powder charges suitable for plain base bullets when fired without their gas check cups.

The .22 Long Rifle and other rim fire cartridges have rather long heels that fit the inside of the cartridge case and one of the problems in loading this type of cartridge is to cause this heel to expand uniformly to the full groove diameter of the barrel. This necessitates using a bullet alloy soft enough to expand with the particular powder and charge with which the ammunition is loaded. As the heels of rim fire bullets are relatively longer and larger than those of gas check bullets, the problems of loading the two types are entirely different.

Gas checks must be quite shallow and their function is limited to protecting the base of the bullet and preventing gasses from melting or getting past the base. If they are made deep, they become in effect bullet jackets and present problems that can not be overcome with ordinary handloading tools. The writer has done at least a limited amount of experimenting with deep gas checks and the results have been very unsatisfactory. It is impracticable, if not impossible, to get a tight enough assembly between the cups and the bullets to prevent some slippage between the two when the bullets are fired, by using any lubricator and sizer or bullet sizing tool. If there is slippage between a deep gas check and the bullet, or between the jacket of a bullet and its core, the accuracy will be poor.

Gas checks can be put on bullets by tapping them on to the bullet bases with a stick but the usual way is to push the gas checks onto the bullets as well as possible with the fingers or press the bases into the cups laid open side up on a table. The seating is completed when the bullets are forced, base first, through the bullet sizing die.

149 Most gas checks have slightly rounded bases and when lubricating them in one of the lubricators and sizers, grease is apt to force its way under the bullet bases unless a recessed inside punch is used to close the gap between the rounded edge of the gas check and the top of the punch. Plain base bullets require an inside punch with a flat surface. I expect that the next few years will find gas check cups made with flat bases, which is the proper way to make them although the present ones work all right.

Hollow Point Bullets. These bullets are cast from the base and may be either plain base or gas check. The hollow point is formed by a slender plug which passes through the base of the mould block, through the point end of the cavity into which it projects. The plug is inserted before the bullet metal is poured into the mould and is withdrawn before the mould is opened. To make such a mould, a drill bushing is necessary. This bushing takes the form of a steel bullet, exactly the same shape and size as the mould cavity, with a hole the size of the drill passing through its center. The hole is drilled and reamed first and the bushing turned and ground on an arbor, so it will be concentric with the hole. The mould blocks are cherried in the usual manner and to a point where the bushing fits the cavity perfectly; then the hole for the hollow point plug is drilled, the bushing serving to guide the drill. This is the only way a hollow point mould can be made or drilled to insure that the hollow point will be in the center of the bullet. Manufacturers can only make hollow point moulds for those bullets for which they have bushings, and they will not make these bushings for any bullet, simply to make up one or two moulds, as the bushings are expensive to make properly. Bear in mind that a bullet, normally pointed, will have the point removed if the mould is made in hollow point form.

Hollow point, in common with hollow base bullets, are a little less convenient to cast than solid bullets. It behooves the caster to work as rapidly as convenient when casting
150 either of them, as the metal must flow into a rather narrow space around the plugs and the plugs, being of small bulk, chill more rapidly than the rest of the mould. Hollow point plugs are slightly tapered to permit their easy withdrawal.

Hollow point bullets are effective for hunting purposes. Their expansion depends upon their hardness, the velocity at which they are driven, or more properly, the velocity at which they strike, and the depth and diameter of the hollow

point. At low velocities, the bullets should be soft. On small game that is going to be eaten, solid bullets are usually best as hollow points destroy too much meat. On the larger animals, the bullets should be hard, with hollow points that are not too deep. If the hollow is too deep the bullet will expand too quickly, causing a large surface wound but lacking penetration; a shallower hollow will permit the point to expand but leave a heavier solid body behind the expanded point to push it on, thereby causing a smaller but deeper wound.

The depth of the hollow point in a cast bullet can be decreased by filing off the end of the hollow point plug, but as this plug is shortened, the weight of the bullet will be increased. Hollow pointing removes weight from the front end of the bullet and moves the center of gravity back toward the base, which is beneficial rather than detrimental to good accuracy. Some bullets that are not particularly accurate when cast solid, are very accurate when cast with hollow points.

Hollow point cast bullets can not be depended upon to break up completely on impact as they can not be driven at high enough velocities to insure this. The safest bullets for use in settled communities are light weight, jacketed bullets with hollow points, driven at the highest velocities possible with safe pressures. Any attempt to make a cast bullet with a hollow point wide and deep enough to cause it to go to pieces upon impact with the ground, or any substantial object, would be of such poor ballistic shape that it would not be accurate at other than short distances.

There is no reason for making a very deep hollow point 151
in a bullet. As the term implies the hollow should be in the point rather than in the body of the bullet. To determine how deep the hollow could be made in a plain base revolver bullet without danger of the bullet blowing through at the base, the hollow points of some bullets were deepened by drilling them out, a flat end drill being used to bottom the holes. The picture on Plate XIII shows the result. As the hollow became too deep, the bullet slugged out of shape and finally the base blew out, blowing the tapered forward portion of the bullet out to a cylindrical form after which the gasses got around the outside of the bullet and collapsed it. A base thickness of at least .100 inch should be left to prevent it from blowing out and with only this thickness the accuracy will be destroyed anyway. I repeat that hollows should be limited to the points of bullets.

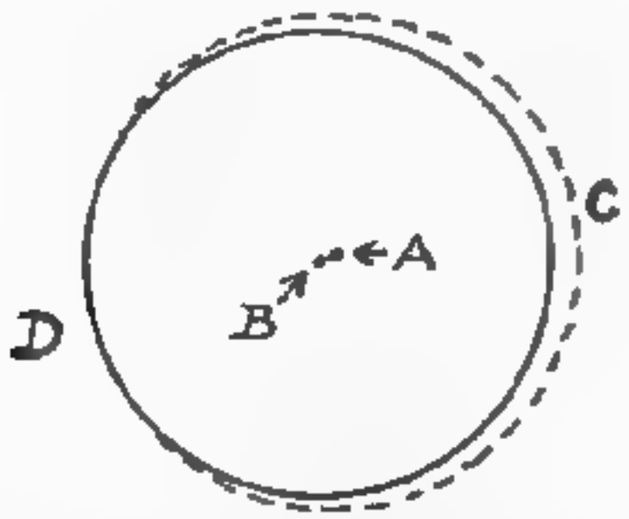
An old trick and a good one for casting expanding point bullets with a mould for a solid bullet is as follows: Lay a strip of thin bond paper across the inside surface of the mould block in such a way that when the mould is closed, the paper will form a septum or division in the point end of the bullet cavity. When the bullet is cast, the paper can be pulled out or torn off leaving a fine slit in the bullet point, but preserving the original shape of the bullet. The depth of the slit can be controlled by the location of the paper strip. If the bullets are soft and they are driven at a fairly high velocity there is a tendency for the points to open up in flight, especially if the slits are deep. To avoid this, the paper strips can be cut narrow and laid across the mould cavity in such a way that a small part of the nose or point of the bullet will be cast solid, the paper strip being entirely surrounded by lead as the bullet comes from the mould. The solid tip will hold the bullet together in flight but will not prevent the point from expanding on impact. By varying the bullet hardness and the depth and location of the slit, almost any degree of expansion may be obtained. The paper between the mould blocks will slightly
152 enlarge the bullet, but as the enlargement will be equal on the opposing sides of the bullet, it can be sized without throwing it off center.

Sizing Cast Bullets.

Now for a word about sizing cast bullets of any kind. Mould cavities are not perfectly round, except by chance, although they are pretty close to it, and different bullet alloys shrink differently on cooling. In casting bullets, the halves of the mould block are not always pressed together exactly alike, especially when casting rapidly, so it is necessary to make the moulds so they will cast bullets slightly over size, later sizing them to the correct diameter to remove the inequalities in them. This not infrequently results in the removal of more metal from one side of the bullet than from the other. Sometimes one side of the bullet hardly touches the sizing die while the other is sheared off in a way that leads the reloader to believing that the sizing dies are way out of line, whereupon he sets up a loud howl that his bullet sizing contraption is no good. Far be it from me to poke fun at the inexperience of any reloader for while the mechanics of hand-loading are indeed simple, there are a multitude of little details that can not be learned in a day. Nevertheless, I am forced to remind the reader that howling is done with the mouth rather than the brain and while sizing dies and loading tools can't always be perfect, they hit a pretty fair average. As this condition of "off-center" sizing of bullets is not uncommon, let's take a careful look at it.

When a bullet is fired, it passes through the barrel revolving around its *center of form* because it is held by the barrel, but when it emerges from the muzzle and is no longer supported, it rotates around the *center of mass*. (Center of gravity). If the center of form or shape and the center of mass or gravity are not the same, the rotation of the bullet will be eccentric. If the eccentricity were the same in all bullets fired, the accuracy would be good in spite of the condition, but this is not likely to be the case. Therefore,
153 one of the problems in making any kind of bullets is to get these two centers to coincide and it is with this object that we size our cast bullets instead of shooting them just as they come from the mould. True, if we do use them as cast, the barrel will do the sizing but it may not do it always the same; one bullet may bear harder on one side than another, etc.

The diagram reproduced below will show why bullets are not necessarily off center because more metal is sheared off one side than the other. The drawing is, of course, grossly exaggerated, but will show the principle clearly. "A" represents the center of mass of the bullet as it comes from the mould and "B" the center of form and we want to get the two to coincide. When the bullet is forced through the sizing die, the side "D" had little or no metal removed



from it while the side "C" is sheared off. The bullet appears to have been forced off center, but actually it is not, and the point "A" has been moved over to "B" approximately. The difference between the two is not often sufficient to affect the accuracy at ranges at which cast bullets are usually fired. It is better, theoretically, if the cast bullet is round to begin with and the removal of metal is equal on all sides, but bullet moulds can not be made to cast *perfectly* round bullets except by chance or at a prohibitive manufacturing cost. Then there is always shrinkage to contend 154
with. Swaged bullets can be made round and to the correct diameter to begin with and they only have to be sized to remove the small amount of metal that is squeezed out when the grooves are rolled into them, but not cast bullets.

Sizing Diameter. Now, about the diameter to which a bullet should be sized. Most hand books on reloading describe methods of measuring the groove diameters of barrels. They do so for the benefit of the fellow who has a special, obsolete, or other anomalous barrel, but it seems as though about fifty percent of the people who read the directions feel that they must measure their barrels before they can get a bullet mould, overlooking entirely the fact that bullet moulds are standardized articles and are not made specially for each barrel. The same holds true to a lesser degree with bullet sizing dies. If you have a modern rifle of any reputable make, there is no need of measuring your barrel. I refer particularly to rifles made in the United States. Even with the Krag and Model 1917 rifles, which vary more than an ordinary amount in their bore and groove dimensions, this holds true.

In revolvers, the barrel dimensions are not the sole governing factor in determining the bullet diameter, as the bullet must be large enough to receive some guiding support in the throat of the chamber. For example, .38 Special Colt Revolvers have a groove diameter of .354 inch, subject to manufacturing tolerances, but they use bullets measuring .358 inch in diameter. If a .354 inch bullet were used, it would receive little or no support in the throat of the chamber and its angular entrance into the barrel would be increased, to say nothing of the evil effects upon the bullet itself from the excessive reduction, of which we will have more later. The standard diameters of revolver bullets have been worked out over a period of time, more by practice than by theory and the novice who sticks to standard bullet diameters is making no mistake. Revolvers, with their separate rotating chambers, present an entirely different problem from rifles and pistols and the two should not be 155
confused.

Somewhere, somehow, the word got noised around that cast bullets for rifles had to be .003 inch larger than the groove diameter of the barrel they were to be fired in. I don't know where it came from but it is the "bunk" and the worst part of it is that the sad news has penetrated deep into the sanctums where bullet moulds are made. There are two very good reasons for making moulds to cast bullets a few thousandths of an inch over size, other than to true them up by sizing. If the cherries with which these moulds are made are a trifle large, they can be resharpened more times which increases their useful life and decreases the tool cost. Also, it permits sizing the bullets a thousandth or so over standard size for the occasional barrel that may run a bit too large for standard diameter bullets. But there is no reason for carrying this too far, as has been done with some bullets.

Thirty caliber bullets, being the size most extensively used, may be taken as an example. The standard groove diameter of caliber .30 barrels is, and always has been, .308 inch. Some barrels in commercial production will run as large as .309 inch and on rare occasions, a little larger. If a .308 inch bullet is centered in a .309 inch barrel, only one half thousandth of an inch will be left on opposing sides of the bullet, (ignoring the expansion that takes place when the bullet is fired) an insignificant amount even with hard jacketed bullets. With lead alloy bullets which, at their hardest, are relatively soft and plastic, this difference in diameters is just about nothing. The correct diameter for flat base bullets for caliber .30 arms is and always has been .308 inch, which is perfectly natural and obvious. Bullet moulds for such caliber used to be made to cast the bullets about .311 inch in diameter, although many of the older moulds will drop their bullets closer to .308 inch. This .311 diameter allows three thousandths of an inch for variations in the cherrying of the moulds, wear of the cherry and 156 allows plenty of excess metal on the bullet for truing it up in a sizing die. Bullets seldom run more than a thousandth of an inch out of round as they come from the mould, so there is still a couple of thousandths for the reloader to play around with if he wishes or needs an over size bullet.

Apparently, because bullets of this caliber were often cast as large as .311 inch, the idea has gotten around that bullets *must* be several thousandths of an inch larger than the standard groove diameter and most of the newer bullets cast large enough to *size down* to .311 inch, which means that they cast around .315 inch. These .311 inch bullets are so large that they make the necks of the cartridges they are loaded in too large to go into the chambers of some commercial rifles. Military chambers are purposely made a trifle large so the arms will surely function with dirty chambers and oversize cartridges, as both of these conditions are found under war time manufacture and service, consequently, .311 bullets will work in such chambers. When bullets are made so large that they can not be loaded into standard chambers it certainly looks as if something was wrong, doesn't it? The common remedy for this fault is to size the bullet smaller, which seems simple enough at first glance, but in reality this is a make-shift remedy with certain serious faults. In the first place, if the diameter of the bullet is too large to begin with, the diameter of the ogive or nose is also too large for the throat or bullet seat

of the barrel and this part of the bullet is not affected by any sizing operation. It not infrequently happens that, regardless of the sizing, these over size bullets have to be seated abnormally deep into the cases, in order to get the cartridges into the chamber, but this is not always a serious fault as far as their performance is concerned.

Bullets will size very nicely if the reduction in their size is not much over 1% of the bullet diameter. This means about .002 inch for caliber .22 bullets, .003 for .30 and .004 for .44 and .45 calibers. These reductions are approximate but if they are exceeded appreciably, the bullets may size irregularly, off center and often the lubrication grooves will 157
be closed up enough to prevent proper lubrication. It is not in the cards to size a bullet that casts .315 inch in diameter down to .308 inch, therefore; the groove diameter of the barrel is not the sole determining factor in sizing bullets; the limitations of the bullet itself must be taken into consideration.

There are a few plain base bullets that are designed to be shot as they are cast and without any sizing whatever, although they must be lubricated. These comments on bullet sizing, of course, have no reference or application to such bullets.

Jacketed Bullets.

Most jacketed bullets consist of two parts; the jacket and the core. Both jacket and core are made separately and assembled to make the complete bullet. Numerous materials have been tried or used for making bullet jackets. Some bullets made in Europe have jackets of soft steel, heavily plated with copper. As the copper plating is more or less porous, such bullets are apt to rust under unfavorable climatic conditions. They are also rather hard on barrels.

The two jacketing materials most commonly used in the United States are cupro-nickel and gilding metal. The former is an alloy of copper and nickel as its name indicates, the nickel content being just about sufficient to give it a white or nickel appearance. Cupro-nickel was used almost entirely for bullet jackets up until the end of the World War. It had two serious disadvantages; it was tough stuff and difficult to manufacture and it had a further disadvantage of building up lumpy fouling in rifle barrels, particularly near the muzzle, when the velocity of the bullets exceeded about 2000 f.s. This metal fouling destroyed accuracy and was difficult to remove. If a rifle were fired long enough, the metal fouling would build up about so much and then shoot out, after which it would build up again. Firing a few bullets at very low velocity would usually take it out but the usual method was to eat it out with a special ammonia solution which, if fresh and not left in the barrel too long, would eat or dissolve the cupro-nickel without harming the steel. The safeguarding of the steel depended upon the presence of a sufficient amount of ammonia gas in the solution and if too much of the gas escaped, the solution would cause rapid rusting of the barrel. This made cupro-nickel bullets a nuisance to the shooter and efforts were made to find a remedy for metal 158
fouling.

The copper rotating bands on artillery projectiles also cause metal fouling and the French, who by the way have been responsible for many advances in the field of ballistics, discovered that if tin foil was put into artillery ammunition, metal fouling could be prevented. The tin, vaporized by the heat of the burning powder, coated the bore and either due to its temporary molten state, its anti-friction properties or both, prevented the building up of lumpy fouling.

The DuPont Company utilized this idea and brought out their I.M.R. Nos. 15½ and 17½ powders, which had metallic tin incorporated in them. The use of these powders does overcome the lumpy fouling of cupro-nickel bullets, but they leave a coating of tin in the bore that is harder to remove than the nickel fouling. This really is of small consequence, as the presence of the tin does no harm and takes the form of a thin uniform plating throughout the bore. It did raise the devil with the ammunition boys for a while, as these tin incorporated powders are hard to ignite properly and most of the primers in use at the time they first made their appearance wouldn't do the trick. With proper primers they are excellent powders, but the tin idea was just a little bit late. The ammunition companies had also been working on the problem from the angle of bullet jacket material and about the time the "tin" powders came out, gilding metal jackets also made their debut.

Gilding metal is a high brass composed principally of copper with a small amount of zinc added. It is not new, nor is its use confined to the making of bullet jackets. It
159 varies in composition according to its use and has long been used in the manufacture of cheap jewelry, as one alloy has the appearance of gold and does not tarnish easily. The alloy used for bullet jackets is composed of about 90% copper and 10% zinc. At first, gilding metal jackets were coated with a very thin coating of tin which was applied by a mechanical process. This coating was hardly of measurable thickness and served only to prevent oxidation or discoloration of the gilding metal. The practice of coloring gilding metal jackets with tin has been discontinued. Western Lubaloy is very similar to gilding metal except that it contains a small percentage of tin in the alloy, which really makes it a bronze. It is to all intents and purposes the same as gilding metal.

(Note. The ammunition made at Frankford Arsenal for the 1921 National Matches had bullets heavily plated with tin. This ammunition was satisfactory when first loaded. Tin has an affinity for brass and in this ammunition the tin combined with the insides of the case necks, forming a union between the bullet and the case just as though the bullets were soldered in place. This union is so strong that it is impossible to extract the bullets and if the ammunition is fired, dangerous pressures will develop. Most of this lot of ammunition, the only one so loaded, has been shot or destroyed, but anyone running across any of it should destroy it or preserve it only as a curiosity in the development of ammunition. It should under no circumstances be fired. The marking on the case heads is, F. A. 21-R.)

Bullet jackets are drawn in much the same manner as cartridge cases. They may be drawn to their finished shape or in the form of cylindrical cups which are later given the proper form. Great care must be taken to have the jackets of a uniform degree of hardness, they must be of a proper and uniform weight when trimmed to length

and the wall thickness must be uniform all around. If too soft for the cartridge they are made for, the bullets will "slug" excessively when fired. Slugging is a bulging deformation of the bullet that takes place in the barrel when 160
the bullet is too weak to withstand the pressure applied behind it. If the jackets are not of a uniform weight, the finished bullets will also vary in weight and if the wall thickness of the jackets are not uniform, the center of mass of the finished bullets will not coincide with their centers of form. There is no object in going into great detail here on all of the problems of making jacketed bullets, in fact, the only useful purpose to be served by this description is to give the reader some idea of what it is all about so he can appreciate the limitations of the jacketed bullets he buys, and load them to get the best results. Each cartridge presents its own problems of bullet manufacture and suffice to say that the jacket of a bullet that must expand on animal tissue when fired with a muzzle velocity of 1700 f.s. must be made differently than the jacket of another bullet of the same weight and caliber that is to be fired at 3000 f.s. Both bullets may *look* alike but that is probably as far as their similarity will go.

Bullet cores are made of lead alloyed with tin or antimony to give it the proper degree of hardness for the purpose that the bullet is to serve. The cores are swaged to form in the same manner that factory lead bullets are made. As the cores come from the swaging machines, samples are checked for weight, as they must be uniform and of the correct weight if the finished bullets are to be correct. Variations in weight are caused by a lack of uniformity of the percentages of the metals in the alloy. The slugs from which the cores are made may be cast in moulds or cut from wire made of the proper alloy, the latter being the prevalent method today.

To make the lead wire, the metals are alloyed in the proper proportions and are cast in cylindrical ingots. These ingots are put into large hydraulic presses which squeeze the metal through a die of the proper size, extruding it in the form of wire, much in the same manner that tooth paste is squeezed from a tube. Great care is necessary in
making the ingots, for when the metal is poured into the 161
ingot mould there is a tendency for the lighter metal in the alloy to rise to the surface, just as it will in a melting pot when casting bullets. This condition will result in one end of the finished wire being of a greater specific gravity than the other. As the shape and volume of the cores is definitely fixed by the dies in which they are formed, the cores from one end of the wire will be much heavier than those from the other end, hence the cores are checked frequently for weight and when they begin to run lighter or heavier than normal, the balance of the wire is discarded.

The slugs come from the swaging machines covered with oil and *all* of this oil must be removed from them before they are assembled into the bullet jackets. The presence of oil between the core and the jacket will result in slippage between when the bullet is fired and good accuracy can not be obtained with bullets in which this condition exists. There must be a tight assembly between these two components.

And that brings up a point. Some reloaders attempt to alter the diameters of jacketed bullets by swaging or reducing them in hand dies, so that they will better fit some particular rifle. While this can be done, at least with a fair degree of success, there is danger of ruining the bullets in so doing. The jackets are of a resilient material while the cores are not, consequently if the bullet is squeezed down to a smaller diameter, the bullet and the core will be compressed together while in the die but when the bullet comes out, the jacket may spring back slightly, while the core certainly will not. The upsettage that takes place when flat base bullets are fired may off-set this condition, but if it doesn't the accuracy will suffer. Boat-tail bullets do not expand or upset when fired and any attempt to change their diameters by swaging them will destroy their accuracy, especially at the longer ranges.

After the cores are freed of oil they are assembled with the jackets, by being forced into them while the jackets
162 are held in dies. If the bullets are of the military or full jacketed type, the cores are fed into the base ends of the jackets; while for soft point, open point or other expanding bullets having separate tips, they are fed in from the point end. The boat-tail, if any, is then formed and the rear of the jacket based over or the point is formed and the bullets are passed through a sizing die. Cannelures for crimping, or for weakening the jacket to promote expansion, are rolled in after the bullets are completed otherwise. Canneluring jacketed bullets, and especially boat-tail bullets, tightens the assembly of core and jacket and improves their accuracy. Special care is necessary when making boat-tail bullets without cannelures.

Now for a word about expanding bullets. Way back in the days when grog shops were called saloons instead of taverns there was a caliber .30 rifle called the Krag which tossed a round nose bullet weighing 220 grains with a muzzle velocity of about 2000 f.s. Sporting or hunting bullets for it and other rifles of the same caliber (.30-40) were made with a liberal exposure of lead at the nose of the bullets. These soft point bullets were, at the velocity mentioned, about the best killers of thin skinned game that we have ever had. The soft points mushroomed beautifully, while the high sectional density (length and weight in relation to the area of the cross section) caused them to plow right on deep into the animal after the point had expanded to about twice its original diameter.

But about the same time we were hit with the velocity craze and no rifle or cartridge was any good if it wouldn't shoot as flat as the proverbial pan cake. At increased velocities, the old soft point bullets weren't so good. The noses flattened too quickly and too much, the lead being spread out and separated from the rest of the bullet on impact. This caused bad superficial wounds, while the rest of the bullet with the lead point eliminated often proceeded on its way like a full jacketed bullet, making a deep but small wound lacking in shock effect.

163 The ammunition boys went to work to make new types of bullets that would not expand so easily and that would stand the higher velocities, and they have been at it ever since—trying to make bullets that, at the velocities at which

they are fired, will produce the expansion and deadly effect of the old soft point bullets. Most of these newer bullets have been unsuccessful; they expand too quickly, destroying too much meat in the smaller animals and opening up or even going to pieces before penetrating into the vitals of the larger ones. There are some very good ones among them and in selecting expanding bullets for loading purposes, the handloader should consider the velocity at which he is going to drive the bullets, as well as the kind of game he is going to use them on. Magazine articles recounting the actual experiences of hunters are a better guide to selection than ammunition catalogues. It is but natural that the ammunition manufacturers should extole the virtues of their products and sort of forget about their faults; we all do that, but the real reason for recommending magazine articles in preference to catalogues is that the *only* way that the effect of a bullet on game can be found out is by shooting game with it and that is what the stories tell. Catalogues are inclined to lay emphasis on bullet energy; and frankly, energy expressed in foot pounds doesn't mean a damn thing in a hunting bullet. It is the way that energy is used up on the animal that counts or in other words, the effect actually produced by the bullet.

A large percentage of shooters never hunt or really expect to hunt big game and such hunting as they do is limited to small animals, some of which are very tenacious of life. If the flesh is to be eaten, it is necessary that as little as possible of the meat be destroyed by the bullet. For such purpose, full jacketed bullets are desirable if the average range be long, as these bullets can be driven at higher velocities than cast bullets, but at the shorter ranges cast bullets driven at as *low* a velocity as is practicable are excellent.

In settled communities this introduces a complication, as 164
loads of this type are apt to ricochet or glance. The distance that a bullet will ricochet to, or the direction that it will take after impact with the ground or any hard object, is a matter of uncertainty. The heavier the bullet, the higher its velocity and the less it is deformed on impact, the farther it will go when it glances. Cast bullets will usually deform more on impact than jacketed bullets and the more a bullet deforms, the greater the air resistance will be and consequently, the shorter the ricochet range. In artillery firing over water, the ricochet range is considered as being about two thirds of the actual range, but such firing is done at long ranges only, nearly the effective range of the gun, and is an unsafe rule to apply to small arms. If one is shooting at a hundred yards with an arm that has an effective range of 2000 yards, it would be ridiculous to consider the ricochet range as 67 yards. I have known of Springfield bullets causing complaints from about two miles beyond where the bullets struck, so when shooting solid bullets, or any bullets at low velocities, it is well to be very careful of the direction of fire and to only shoot when there is a good back stop for the bullets.

There is another bad feature of ricochet bullets: If they are deformed much on impact, they make a peculiar whining noise as they go through the air and this sound can often be heard for a considerable distance. I have yet to see an innocent by-stander who has heard a bullet ricochet that wasn't ready to swear by all that is holy that it went right past his ear.

The safest loads to use in a settled community are light weight, open point, jacketed bullets driven at the highest velocity possible with safety. Such loads will almost always cause the bullets to go to pieces on impact; but bullets sometimes behave in a freak manner and very, very rarely one of these light open point bullets will glance. When using them it is still necessary to use care and judgment in shooting, even though the chances of getting a ricochet
165 are remote. These bullets go into such small pieces that the fragments lack the weight or energy to go very far and they offer considerable air resistance in proportion to their size. The trouble with these loads is, that they are ruinous to small game and will practically blow it to pieces. They are excellent for rodents and predatory animals whose meat or fur has no value. What the small game hunter wants is a high velocity load having a flat trajectory, that will kill cleanly without destroying meat, and that will go to pieces on impact with the ground; but it can't be done. Cast bullets, including gas check bullets, can not be driven at very high velocities nor have they particularly flat trajectories. One can't beat the game by using short, light weight, gas check bullets for such bullets must be driven at *lower* velocities than the longer ones in order to get good accuracy. They will kill cleanly but they will not break up on impact. Full jacketed bullets can be fired at high velocities and will kill cleanly as a rule, but they will not break up and will ricochet a long way. The heavier, expanding point bullets can be loaded to give flat trajectories, but most of them will open up more or less, even on small game, and destroy meat, if not the entire animal. Their *points* will break up on impact with the ground but the body of the bullet will not. For instance, a 150 grain, cal. .30 open point bullet will, on impact with the ground, usually have the point disintegrate but the resultant or remaining slug will weigh about 90 grains, and a 90 grain slug can travel a long way and do a lot of damage. The light weight, open point, jacketed bullets can be fired at high velocities and will break up on impact, but they will also break up on and raise the devil with meat. So there you are and take your pick.

There is, of course the question of the hollow point cast bullet but suffice it to say that these can not be driven fast enough to break up with certainty, although they will usually flatten or partially disintegrate to a greater extent than solid bullets, when fired at the higher velocities.

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PART TWO

Ammunition Assembly

Chapter Five

BULLET ALLOYS.

Lead forms the basis of all cast bullet alloys but lead alone is not well suited for making bullets. In the first place, pure lead does not flow well or fill out properly in

a bullet mould and bullets cast of pure lead are apt to have rounded edges. Furthermore, there is a considerable amount of shrinkage when pure lead cools and, if a bullet mould happens to be small enough to cast a bullet of the correct diameter to use without sizing, a bullet of pure lead from this mould will be found to be somewhat under size. In addition, lead is very soft and bullets cast of it are easily damaged in handling, are likely to be scraped or sheared when being seated in the mouths of cartridge cases, and there is a tendancy for pure lead to rub off in streaks on the inside of the bore, leading the barrel and rendering it inaccurate. I do not mean to say that lead bullets can not be used, merely that in general bullets of pure lead are more difficult to cast and are less desirable for use than those cast from an alloy of lead and other metals. The metals most commonly used with lead for making bullet alloys are tin and antimony, either or both being used at times.

Tin. Tin is a convenient metal to use in making bullet alloys because of its low freezing point. Tin possesses certain anti-friction properties that slightly reduce the probability of leading, although care must be taken in using the tin so as to avoid excess in the alloy. As an 168
example of the anti-friction properties of tin, which is commonly used in bearing metals because of this quality, brass (copper and zinc) is almost worthless for bearings; but bronze, (copper and tin) make excellent bearings. The same is true of Babbit metals, as those containing tin are used in high-speed bearings while the so-called lead Babbit can only be used in low speed bearings. The addition of tin to lead hardens the mixture and its hardness will increase as the percentage of tin increases. Lead and tin will form a true alloy, that is, they will mix together when the metal is in a molten state and remain mixed after the metal solidifies. This is known as a solid solution, but lead will only retain about 11% of tin in solid solution. If more than 11% of tin is used the excess tin will crystallize out in the form of pure tin crystals when the metal cools. These crystals will be more or less evenly distributed throughout the alloy. About 10% of tin, or roughly, a mixture of 1 part tin to 10 parts lead is about the hardest lead-tin alloy that it is practicable to use for bullets; and this mixture is unnecessarily hard for most purposes. This 1 to 10 alloy of tin and lead has a further objection in that its melting point is rather low.

The reader should not get the idea that tin, because of its anti-friction properties, is a panacea for leading. It is not. I believe, from long and careful observation, that a little tin, judiciously used, will reduce the chances of leading in most arms. On the other hand, I know that too much tin may actually cause leading. Tin and lead form solder and while an alloy containing only 10% of tin is hardly comparable with commercial solders, particles of such an alloy will sometimes melt under the heat of powder gasses and adhere firmly to the bore. This is especially true of revolvers, for reasons to be pointed out later.

Antimony. Antimony makes an excellent hardening agent for bullet alloys, it is used almost entirely as a hardening agent for lead bullets as produced by the ammu- 169
nition companies and, despite the fact that antimony does not have the anti-friction properties of tin, it is nevertheless an excellent hardening agent for bullets when used alone. Antimony will not form a true alloy with lead. The two metals will only remain in solution as long as the alloy is in a molten state; when it cools, the antimony will separate out in the form of antimony crystals distributed throughout the mass of lead, but this is not prejudicial to the casting of good bullets.

Antimony has a certain advantage over tin for alloying bullets in that it is cheaper and need only be used in small percentages and that it will make harder bullets and bullets with a higher melting point than those made from an alloy of tin and lead. The principal objection to its use is its relatively high freezing point (or melting point) which is roughly double that of lead. The presence of antimony in the bullet alloy makes the metal free flowing and permits it to fill out the mould cavity more completely than alloys not containing antimony, as there is a tendancy for antimony alloys to expand slightly on cooling rather than to shrink.

Copper. Copper is of little use in bullet alloys. Years ago, the Ideal Manufacturing Company of New Haven used to sell a bullet alloy containing copper, they recommended it for use in making gas-check or other bullets which were to be driven at a relatively high velocity; but the fact of the matter is that copper will not alloy with lead and if copper is used in a bullet alloy it will only take the form of more or less irregularly divided particles usually distributed unevenly throughout the mass of lead. These particles of copper will not melt at temperatures which can be obtained on the kitchen range and the fact that the use of this metal has long since been discontinued is sufficient evidence of its faults.

Mercury. Mercury has at times been suggested as a hardening agent for bullets but I cannot urge the reader too strongly to keep away from any attempt to use mercury 170
for this purpose. Properly used, a very small percentage of mercury will harden lead.

But mercury in the bullet will attack the brass of the neck of the cartridge case and, furthermore, *mercury under no circumstances should be applied to molten bullet metal* as it will immediately vaporize and the mercury vapor, if inhaled, will prove fatal. There is no remedy for it once it is inhaled. There is a method of gilding brass articles by applying a soft amalgum of gold and mercury to the brass after which the latter is heated and the mercury expelled; but in plants where this is done, extraordinary methods are employed, not only to recover and condense the mercury vapor but also to carry off any fumes from it. Where the apparatus is defective or the ventilation insufficient, many deaths have been known to result.

Arsenic. Arsenic is also good for hardening lead, from 1½% to 2% giving a satisfactory degree of hardness for all ordinary purposes. The melting point of arsenic varies and is usually higher than that of antimony, although the sublimed product melts at a lower temperature.

This metal is poisonous and begins to volatilize at

100°C., the volatilization increasing with the temperature. Just what effect the vapors produce on the respiratory system I don't know, but they are probably injurious.

Both mercury and arsenic have their proper uses in the field of metallurgy but are best left in the hands of those who have the knowledge and facilities to use them properly. Antimony and tin are available almost anywhere, they are satisfactory hardening agents, are safe and convenient to use, and the reader should depend upon them entirely.

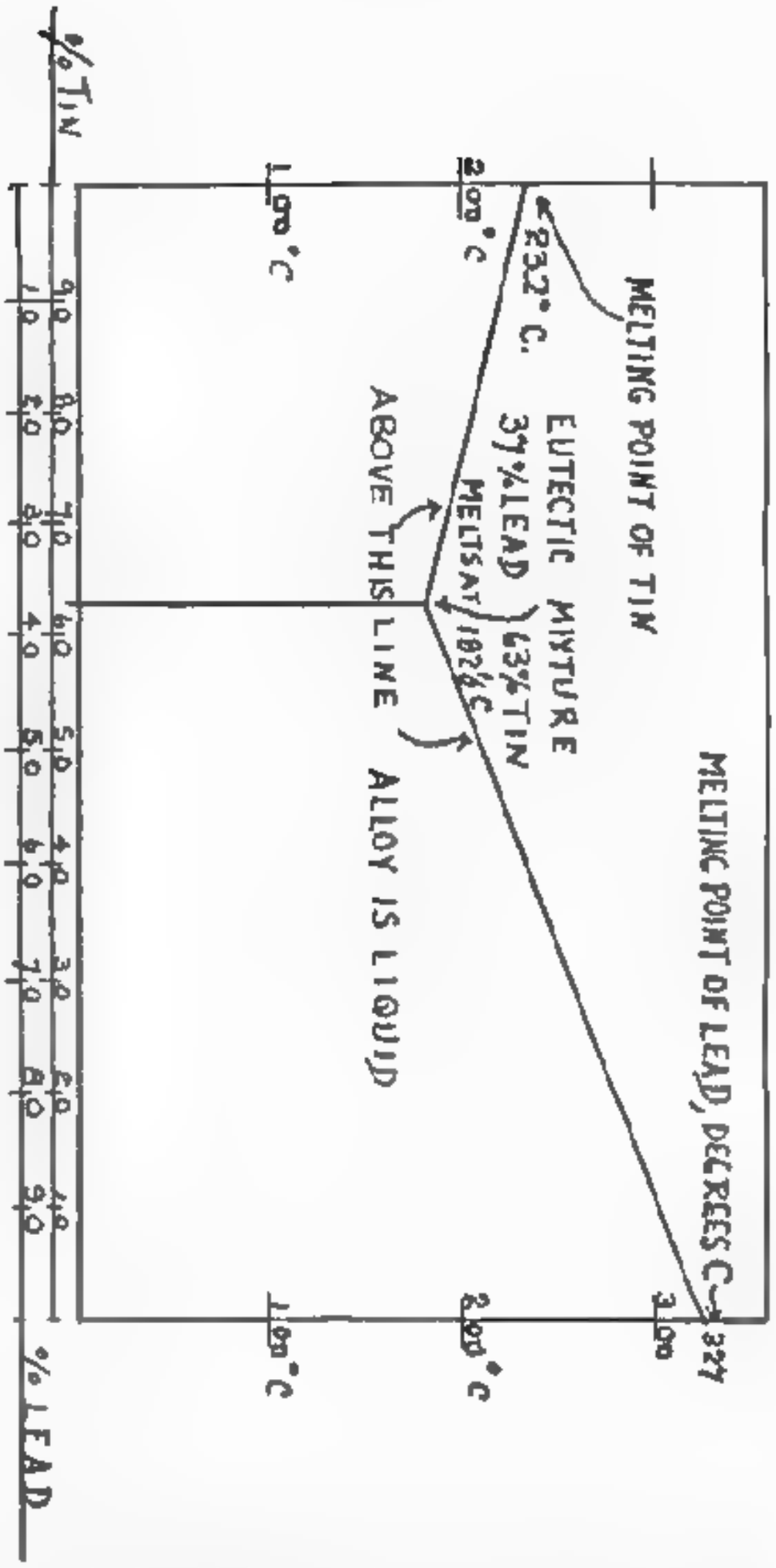
Melting Points.

In casting bullets, particularly bullets that are to be driven at high velocities, the hardness of the bullet is usually the only thing which is taken into consideration but it is well also to bear in mind that the melting points of different alloys are also of importance. The burning temperatures of powder charges, even those developing low 171
pressures, are greatly in excess of the temperatures necessary to melt any lead alloy bullets, the only reason the bullets do not melt is because of the short period of time the bullet is subjected to this intense heat. While the difference between the melting points of different lead alloys is insignificant in comparison with the high burning temperatures of powder charges, nevertheless a difference of a few degrees in melting temperature may make the difference between a bullet that is accurate and performs satisfactorily, and one which leads the barrel and is inaccurate.

To better understand how the melting temperature of bullet alloys is affected by the alloy, there are quite a number of metals whose melting points (or freezing points) are lowered when other metals are alloyed with them. The terms "freezing point" and "melting point" really mean about the same thing. The freezing point of water is zero C., at which point ice is formed. If the temperature rises at all above this point the ice will melt; this condition holds true of metals and the temperature at which metals *solidify* is called the freezing point. Obviously their melting point is at about the same place, so for practical purposes the two terms are interchangeable.

Lead has a melting point of 327.4° C. while tin has a melting point of 232.0°C. But if a small amount of lead is added to a mass of tin, the melting point of the alloy will be lowered below that of the tin; likewise if a small amount of tin is added to a mass of lead, the melting point will be lowered below the melting point of pure lead. Now if we consider the melting point of lead as a point on the side of a square and the melting point of tin as another point on the opposite side of the square, at the proper relative height from the base of the square, and we continue to add lead to the tin side and tin to the lead side, the melting points of the alloys thus formed continue to drop until the two curves formed by the points will meet. This point of junction is known as the "eutectic point." The alloy corresponding to the composition at which the two lines meet is called the "eutectic alloy" and the temperature is the "eutectic temperature." The eutectic alloy is, therefore, the lowest melting alloy in a series.

Perhaps a simpler way of explaining this would be to



173 say that, as tin is added to the lead, the melting temperature i. e., the lowest temperature at which both metals are completely melted, drops until the eutectic point is reached after which the melting temperature rises, as more tin is added. When the other end of the curve is reached the lead will have decreased to nothing and the tin increased to 100%, so the melting point will be that of pure tin.

The eutectic alloy of lead and tin is a composition of approximately 63% tin and 37% lead, the melting point of this alloy is approximately 182½°C. The melting point of an alloy composed of 90% lead and 10% tin, which is about the hardest that can be used satisfactorily for bullets, is roughly 228°C. I do not know the exact figures off hand but those given are approximately correct.

The same condition exists with alloys of lead and antimony. If a curve is plotted in the same way with these metals and the freezing points of different alloys measured, the freezing points on the antimony side will become lower as lead is added and on the lead side the temperature will

be lowered as antimony is added until the two lines meet. But in this case the eutectic alloy is composed of about 87% lead and 13% antimony and the eutectic point is about 240°C.

In making antimony alloys it is only necessary to use about 5% antimony to 90% of lead to get good hard bullets and such an alloy will have a melting point—or the point at which both the lead and the antimony are completely melted and in solution—of approximately 300° C., and with a smaller percentage of antimony the melting temperature will be very close to that of pure lead. From 174
this it will be seen that antimony alloy bullets have an appreciably higher melting temperature than those made from lead and tin.

Alloys of two metals are known as binary alloys but if lead, tin and antimony were used together in a bullet alloy—which can be done advantageously—the alloy would become a ternary alloy and the status of such alloys are so involved that no attempt can be made to give any specific figures or melting points for different combinations.

When an alloy of two or more metals is used at too low a temperature it may be sluggish in action and have a slushy appearance; and it is for this reason that coal ranges and gas or gasoline stoves have been suggested as better than electrical melting units for casting bullets, although some of the latter do work satisfactorily if the volume of metal is not too large.

Oxidation and Specific Gravity.

Lead oxidizes readily in the presence of air, taking up oxygen from the atmosphere, which, in the molten state, forms lead monoxide. This makes its appearance first in the form of a scum on the surface of the metal, the scum gradually darkening and finally turning into a brown powder which floats on the surface. The hotter the metal becomes, the more rapidly this oxide forms.

In its solid state, lead tarnishes rapidly. While the coating forms speedily, it does not increase in thickness much, even though the lead is exposed to the air for a long period of time. Old bullets will often have a hard, dark grey coating on them, but if this coating is cut through it will be found to be very thin. It is of little consequence and is only mentioned as an example of the oxidizing properties of the metal. The presence of even as small an amount as 1% of antimony greatly reduces the corrosion of lead. Incidentally, an alloy of from 1% to 1½% of antimony and the balance lead makes a very good bullet alloy and is about that used in factory revolver bullets.

Tin does not oxidize readily, either in the molten or 175
solid state, and its presence in bullet alloys also helps to reduce the oxidation of the lead. While it volatilizes slowly at red heat, it does not do so at temperatures at which bullet alloys are ordinarily used.

The three metals just referred to are all of different specific gravities. Lead is by far the heaviest of the three, tin comes next and antimony is a little lighter than tin, volume for volume. If tin, antimony or both of them are added to molten lead and melted in it, an alloy is formed and all of the metals may be thoroughly mixed together. But if the molten alloy is allowed to stand, the lighter metals will tend to rise toward the surface, leaving the alloy rich in lead at the bottom and rich in lighter metals at the top. If the melt is allowed to cool and the resultant block of metal is sawed through the center, polished and etched, examination will show the bottom of the pot to contain some antimony crystals surrounded by lead-tin eutectic. Toward the top the antimony crystals will increase in density and possibly tin crystals will appear (if the alloy has stood long enough for a sufficient amount of tin to rise to the surface) separated by eutectic.

Therefore, to get bullets of a uniform alloy and consequently of a uniform density and weight, it is necessary to keep the molten alloy well stirred.

Preparing Bullet Alloys.

Lead-tin alloys are the easiest to make, because of the low melting points of these two metals. It is only necessary to weigh out the proportions of each metal desired, melt the lead and then add the tin, which will melt immediately. The alloy should then be fluxed and stirred thoroughly before using.

The preparation of antimony alloys is a little more difficult and requires a *hot* fire, because of the high melting point of the antimony. The proportions of lead and antimony should be weighed out and the antimony broken up as finely as possible by pounding and pulverizing it
176 with a hammer. Melt the lead and bring it almost to a red heat, then add the antimony which will float on top of the lead. The entire surface of the pot should then be covered with powdered charcoal and the heat increased to a point that will bring the lead to a red heat. Stir the metal occasionally, being sure to keep the top covered with the charcoal, for if the lead is exposed to the air when heated to such a high temperature it will oxidize very rapidly. When the antimony is all melted, let the metal cool down, skim off the charcoal and flux the alloy thoroughly before attempting to use it. If tin is to be added to the antimony alloy, it should be put in after the alloy has cooled down considerably. Once the antimony alloy has been made it can be remelted easily.

Fluxing.

Fluxing serves a double purpose: It makes the metal flow more freely and also removes impurities from it. Salamoniac, hydrocarbons in the form of waxes and fats, and rosin are all useful for this purpose. The most convenient for the handloader is probably bullet lubricant, bees wax or tallow, any of which work equally well. When a scum begins to form on the surface of the metal, the heat should be increased, some fluxing material should be dropped into the pot and the melt stirred thoroughly. The smoke given off from wax or grease can be ignited and greatly reduced. I don't profess to know much about the chemical effect of fluxes, but in the case of hydrocarbons a considerable part probably turns to carbon which, in turn, absorbs oxidizing gasses in the metal at the same time causing the molecules to slide more freely on one another thus promoting the fluidity of the melt. Anyway, whatever the cause, the result is to cause the scum to disdisappear, the oxides to rise to the surface in the form of a dark powder and the metal to flow more freely. The

oxides can be skimmed off, leaving the metal bright and clean.

An alloy should never be skimmed without first fluxing, as otherwise some of the richest part of the alloying 177
metals will be taken away.

Temperature of Alloy.

Watch the heat. As has already been stated, antimony will only form a true alloy with lead when it is melted and as the metal cools the antimony crystallizes out. Tin will form a true alloy if the tin does not exceed 11% If any antimony alloy is used at too low a temperature the antimony crystals will start to form and float on the top of the melt in the form of a sludge. The same condition can occur with a lead-tin alloy, in which case the lead crystals begin to form first. No amount of fluxing will overcome this, as it is the temperature which is at fault.

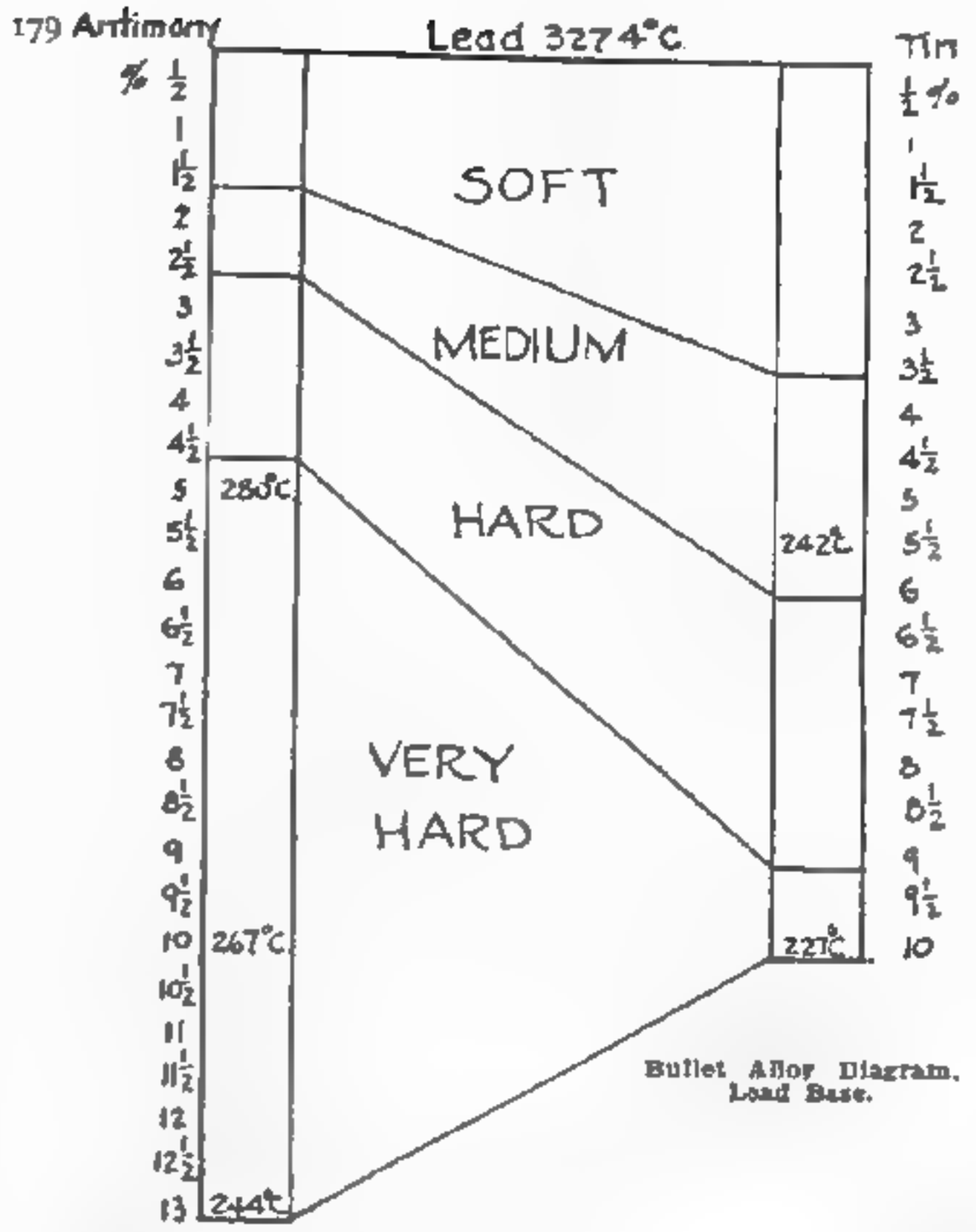
Always keep in mind that the stirring incident to fluxing metal cools the melt, so use a source of heat which will be more than adequate for the alloy you are using. Also remember that it is not alone the quantities of metals that you put into the pot which counts *but where those metals are after they are in there* and they must be kept thoroughly mixed in order to get the most uniform bullets.

Suggestions for Beginners.

An alloy of 1 part tin to 20 parts of lead makes a good mixture for all around use with plain base bullets for rifles, pistols or revolvers. For gas-check bullets in mid range loads (the heaviest loads than can be used behind such bullets), use 1 part of tin to 10 parts of lead. A better alloy for this purpose is one made from 1 part of tin, 1 part of antimony, and 20 parts of lead. This is the same as Number 2 Ideal bullet metal which is composed of 90% lead, 5% tin and 5% antimony and which is used extensively for gas-check bullets. This makes an alloy suitable for almost any kind of bullet and one which is fairly hard. Generally speaking, fairly soft bullets can be used satisfactorily in revolvers but with heavier loads Number 2 Ideal metal bullets should be used in such arms, as there is less tendency for the hard bullets to upset and to expand between the cylinder and the barrel. It is not necessary 178
to be too fussy about alloys for revolver bullets as a bullet made from almost any alloy within reason will shoot well in a revolver if the bullets are properly lubricated. This is also true for bullets for automatic pistols, although the harder alloys are usually preferred for this purpose.

For rifles, moderately soft bullets are quite satisfactory for black powders and low velocity smokeless loads, but if the velocities are increased the bullet mixture should be hardened.

Some rifles are quite temperamental. If your bullets are properly cast, lubricated, and loaded but do not give accuracy, try softening the alloy by adding a little lead to the mixture and see if the accuracy improves. Should the softer bullets make worse groups, harden the alloy and try again. Experimenting in this way will enable you to find the alloy that is best for *your* particular rifle. Before changing the alloy, make sure that your barrel is not lead-



Bullet Alloy Diagram, Lead Base.

The above diagram is intended to give only an approximate comparison of the hardnesses of lead-tin and lead-antimony alloys. The addition of tin to alloys on the antimony side will probably throw the alloy into the next higher hardness group. The same is true of antimony added to the lead-tin groups.

Bear in mind that such terms as soft, medium and hard are purely relative. There is no sharp line of demarkation between them and just at what point an alloy ceases to be "soft" and becomes "medium" is purely a matter of personal opinion. The melting points given are approximate.

180 ing. If it is, clean the lead out with a brass wire brush, or with metallic mercury and then read the chapter on bullet lubricants before proceeding further.

This little chapter being for beginners I have decided to disclose a deep, dark secret. All this stuff about bullet alloys, melting points and the characteristics of different metals, etc., is apt to be very confusing to a beginner and create the impression that casting bullets is a rather tricky problem. As a matter of fact it is nothing of the kind and to help set the reader's mind at ease on this point, I will disclose, for the first time, and in the strictest of confidence, just what I use myself for casting bullets for ordinary shooting purposes.

I have a lead pot which I usually keep at least half full of bullet metal. What it is composed of, the Lord alone knows. If I want to cast some moderately soft bullets, I stick my thumb nail into what is in the pot (y'understand Brother, this is before it is melted) and if it doesn't indent easily enough to suit me I heave some lead in. On the other hand, if it is too soft for what I want, I chuck in some antimony alloy, or a little tin, or any odds and ends that are lying around which I think will bring it up

to the proper hardness. Following this procedure the alloy is ever changing and is ever of unknown quality. However, the bullets usually seem to go where the gun is aimed when it goes off and I don't get any leading, so it will be seen that the preparation of bullet alloys need not be complicated nor highly scientific.

Occasionally, this conglomeration of metals doesn't give quite the accuracy that I think I ought to get from a particular arm, so then I go into the careful preparation of some new bullet alloys.

The objection to using an unknown alloy of this kind is limited to the inability to reproduce it if it proves to be particularly good in some arm. I do not believe it is necessary for a handloader to keep a mass of complicated records on bullet alloys. The average shooter probably does not reload ammunition for more than three or four different arms and can easily remember what he uses for bullets in each one. In experimental work it is, of course, necessary to keep records in great detail, but these folks who reload ammunition for inexpensive shooting and for all ordinary purposes do not experiment to any extent which requires this. Once they have an alloy that is satisfactory (which is usually the first batch they mix up) they stick to it and their troubles with alloying bullet metals are over with.

Hollow base bullets in which the cavity was carried too deep. When fired, the bullet slugged badly or the base blew out and the sides collapsed.

The difference between well and poorly designed lubrication grooves and properly sized bullets is not always apparent until after the bullet has been fired. The bullet on the right has its grooves practically closed up

PLATE XIII.

Commercial Metals and Alloys.

Many handloaders are situated in localities where they cannot buy tin or antimony easily, and they may wish to use scrap lead or commercial alloys of lead. When one reads of bullet alloys made of definite proportions of metals, the idea is sometimes created that it is necessary to be very precise about one's alloys. This is true in the case of an occasional rifle that may happen to be cantankerous. In general, any alloy that can be cast into
181 bullets which shoot accurately is a good bullet alloy, even if it has cheese in it. But, in order that one may have some idea of what he is using, the following composition of common commercial alloys are given. These alloys are apt to vary, but the data given is a good average.

Pig Lead. Name given to commercially pure lead. About 99.6% lead. Melting point, 327.4° C. (621° F.)

Block Tin. Practically pure tin. The impurities are negligible from a bullet casting standpoint. Melting point, 231.9° C. (447.8° F.)

Antimony. Contains traces of other metals, but is essentially pure antimony. Melting point, 630.5° C. (1167° F.). Compare the melting point of antimony with those of lead and tin and you will see why this is a difficult metal to work with over the kitchen stove.

Block Lead. As sold by plumbing shops, this may contain anything. It is scrap, melted up. Try indenting it with the thumb nail; if soft, harden as desired. If it is fairly hard, try it as it is. It is better to get pig or pure commercial lead, if available.

Lead Pipe. This is made of commercially pure lead.

Cable Sheathing. Practically the same as lead pipe.

Storage Battery Plates and Grids. 9% to 11% antimony, balance lead.

Storage Battery Connectors. These are softer than the plates and grids. About 3% antimony and the balance lead. Make a very good alloy for all-around use.

Type Metal. About 82% lead, 3% tin and 15% antimony.

Linotype Metal. Composed of 4% Tin, 11 to 11½% antimony and the balance lead. Melts at approximately 450° F. Brinell hardness 19.0 at 20° C. This alloy is all right just as it is for very hard bullets. As it is used extensively by newspapers, it can be obtained almost anywhere newspapers are printed.

Monotype Metal. 8 to 9% tin, 17½ to 19½% antimony, balance lead. Brinell hardness 22.5 to 23.0 at
182 20° C. Melting point about 460° F. While this alloy is unnecessarily hard for bullets, it can be used just as it is. It is not used as commonly as linotype metal.

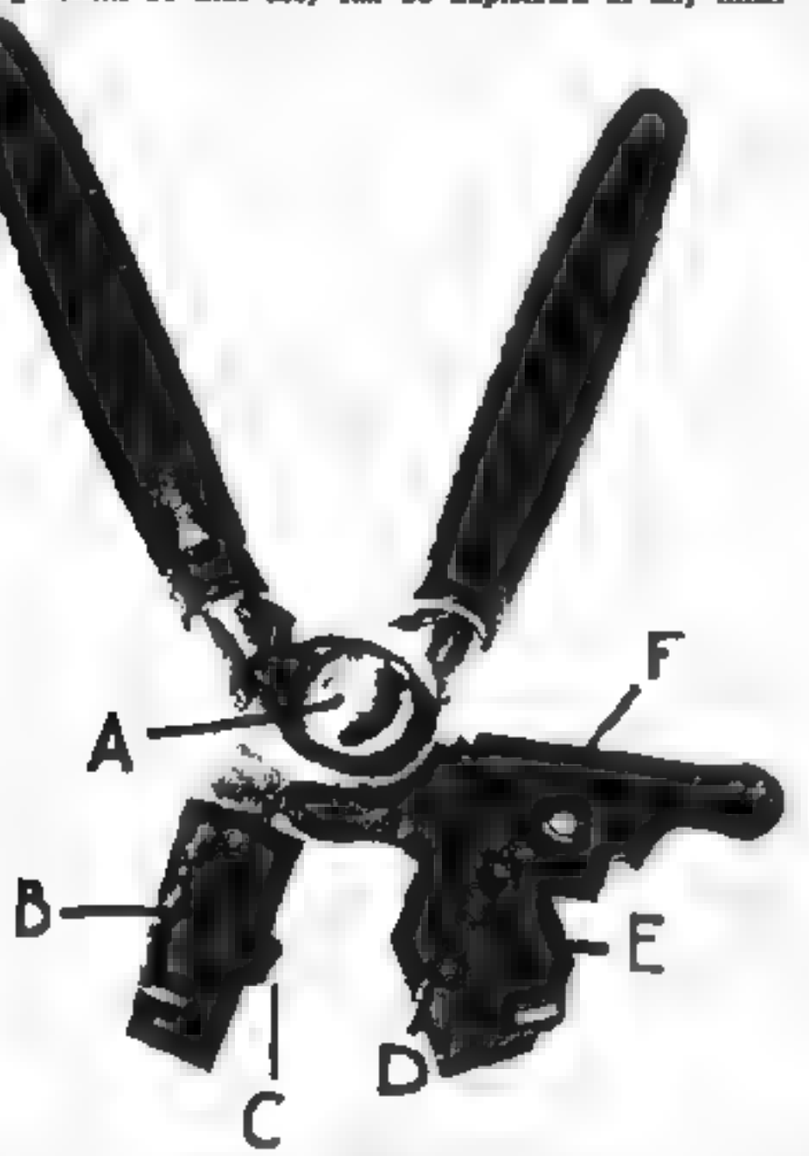
Wiped Joints. When sawed from the pipe and melted, will be from 10% to 15% tin and the balance lead.

Babbit Metal. Varies a great deal. That for heavy duty bearings runs around 83% tin, 11% antimony, and 6% copper. For low speed bearings, lead is substituted for the tin. The copper will never melt, but will be suspended irregularly through the mass as minute particles.

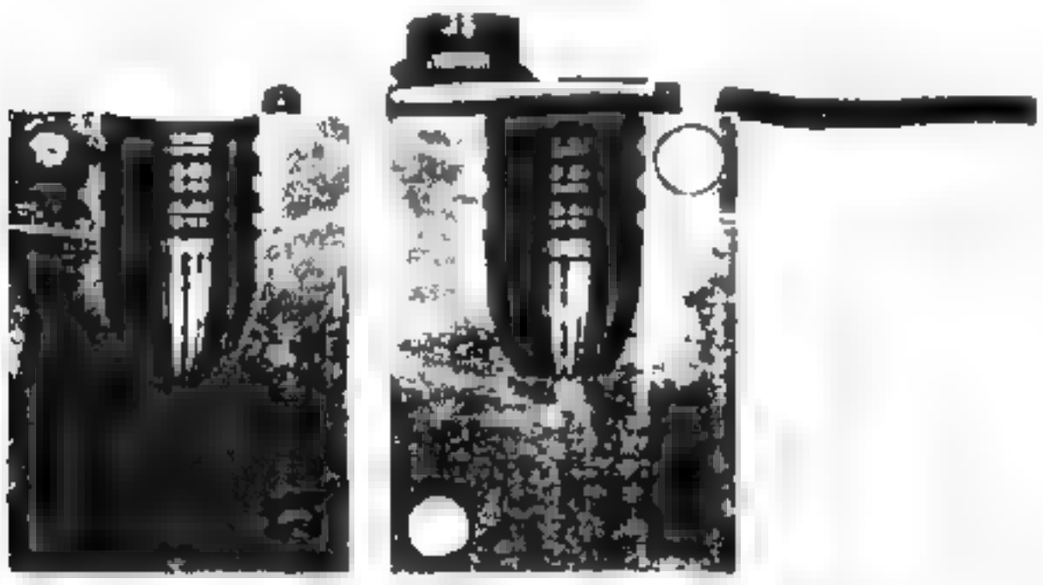
Plumbers' Solder. Used for wiped joints. 67% lead and 33% tin.

Cal. .22 Bullets. Mostly of lead, but recently a lot of hard bullets have been put on the market. Antimony is used mostly for hardening them. Treat in the same way as block lead.

The reader should bear in mind that practically all of the commercial alloys in common use vary considerably in their composition and the best that can be done in such a brief space is to give a composite of information obtained from reliable source. While these miscellaneous alloys can be used and doctored up for making bullets, it is far better to use alloys of known ingredients so that they can be duplicated at any time.



Modern Bullet Mould.
A—Hinge. B—Block half C—Alignment dowel pin. D—Cavity. E—Top surface of mould blocks. F—Swinging gate, with sprue cutter.



Illustrating mould which cast imperfect bullets and which has been "vented" to remedy the defect.

PLATE XIV.

Chapter Six

THE CASTING OF BULLETS.

If all bullet moulds were the pink of perfection and *if* all bullet alloys flowed smoothly and alike and were the same temperature, the casting of bullets would be a very simple matter. It would only be necessary to melt the bullet metal, pour it into the mould and dump out a perfect bullet. While bullet moulds, as they come from the manufacturer today, cannot be considered as faulty and are very well made, each mould manufactured has its peculiarities and individualities. Different alloys of bullet metals do not all flow alike and cannot be used at a uniform temperature. Therefore, there is a little trick to

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casting good bullets that can only be learned by experience. While it will be possible to set down here certain principles, no amount of copy or directions can ever take the place of a few hours' actual experience in casting bullets.

The materials necessary for casting good bullets are: a bullet mould; a dipper or ladle, preferably one made especially for the purpose as supplied by many of the reloading tool manufacturers and having a tubular spout, and a melting pot. A stout stick of wood about ten or twelve inches long is necessary for striking the sprue cutter; some wax or sal ammoniac for fluxing the bullet metal; a soft pad to drop the bullets on; an old box for the dross or oxidized metal that must be skimmed from the pot from time to time; and a source of heat for melting the bullet metal.

184 *Source of Heat.* The old-fashioned kitchen stove is sometimes criticized because of inability to control the heat accurately but this criticism is not justified because it is possible to control the heat of a coal fire by opening the drafts to increase the heat, or by checking the fire, or even by tipping the stove lids to decrease the heat and once the proper temperature of metal is obtained the even heat of a coal fire is very satisfactory. Of course, a gas or gasolene stove is more readily controlled and a little more convenient but is not a necessity.

Electric heating units are not as desirable as a gas flame as a general rule, for sometimes in casting bullets and in the preparation of metals and bullet alloys, an excessive amount of heat is necessary and electrical units are usually a little deficient in the heat that they produce. The ordinary electric stove is worthless, because the pot must set on top of the heating element so that only the bottom of the pot is heated while the greater area of the sides is cooled by the circulation of air. The small electrical bullet casting units are satisfactory in general but are not adequate for preparing bullet alloys and when they are used the bullet metal should be mixed and prepared over a hotter fire and then cast into small blocks of a convenient size for use in these small elements. A suitable mould for the purpose can be made from a square box filled with damp sand pressed down firmly and with depressions made in the sand with the end of a broom handle. It should be borne in mind, however, that none of these electrical bullet casters have sufficient clearance beneath them to accommodate the conventional type of hollow-point bullet mould although they work quite nicely with all other types.

The principal objection to these electric bullet casters is that the metal is always drawn from the bottom of the pot. They are all made in the form of a small ladle or pot with a spout in the bottom. This little pot is surrounded by an electric heating element and is raised up on a support so that the mould can be inserted beneath
185 them with the pouring hole placed against the end of the spout. The spout is closed by a plunger passing down through the metal and the plunger is raised by means of a lever to permit the molten metal to flow out into the mould. To keep the alloy uniform, the metal must be fluxed and stirred frequently and with such a small amount of metal this cools the melt considerably. If the

metal is not stirred frequently the lighter metals will rise towards the surface and a lead-rich mixture will be drawn from the bottom of the pot. They are, however, mostly satisfactory and are very handy for casting bullets, but like every other piece of reloading equipment they must be used with due consideration to the results that are to be accomplished.

The ordinary melting pots and pouring ladles, while perhaps less convenient, will nevertheless, be best to use providing the source of heat is adequate, but here again they must be used properly. The larger volume of metal in the conventional melting pot can be kept at a more uniform temperature than in the diminutive electrical units and can be fluxed frequently without reducing the temperature of the melt below a satisfactory working point. But any advantage of the old fashioned lead pot is offset if the reloader continually dips metal from the surface of the pot, as is so often the case. Go to the bottom of your pot to fill your ladle as the movement of the ladle through the melt will help materially in keeping the metals thoroughly mixed.

Melting Pots. The lead pot should hold at least five pounds of bullet metal and preferably ten, as where the volume of metal is large a more uniform temperature can be maintained. This also permits the addition of new metal from time to time, without lowering the temperature of the metal below a set working point. Suitable lead pots can be obtained from any of the reloading tool manufacturers at small expense, while larger ones may be obtained from any plumbing supply house.

Pad for Hot Bullets. A pad must be provided on 186
which to drop the bullets from the mould. The hot bullets are quite soft and are easily damaged and must not be allowed to strike a hard surface or to strike against each other. A piece of old blanket folded a few times is excellent but if a good blanket is used it should be covered with an old piece of cloth to prevent soil and scorch. If you have a work shop or are situated so that you can have a few extra gadgets around without getting too many blessings from the family, a good bullet catcher can be made by stretching a piece of canton flannel, or any other soft cloth of good strength, across the top of a wooden box and tacking it in place around the edges. Bullets dropped on this will roll toward the center gently and when the accumulation of bullets becomes too heavy they can be removed carefully with a tablespoon.

Flux. Any kind of wax suitable for making bullet lubricant, powdered sal ammoniac or rosin make good materials for fluxing bullet metal. The waxes have a slight advantage in that the smoke produced can be ignited and burned; but you must resign yourself to some more or less unpleasant odors if you intend to cast your own bullets. Bullet alloys are mixtures of lead and tin, lead and antimony, or all three of these metals. As the lead is the heavier of the three there is a tendency for the lighter metal to rise to the surface of the pot. The heat will also cause the metals to oxidize on the surface and these oxides form a scum on top of the metal that must be removed from time to time. The tin and antimony serve as hardening agents and they must not be skimmed off as this will change the hardness of the bullets. Fluxing the alloy will release the metals and leave the oxides in the form of black powder floating on top of the pot, which can be easily skimmed off with a bullet ladle leaving the alloy clean and bright. Experience will show the proper amount of fluxing material to use but the pot should never be skimmed without first fluxing the metal.

187 To do this, drop a piece of wax or a small amount of rosin or sal ammoniac into the pot and stir the metal rapidly. If wax is used, the gasses given off may ignite from the heat of the metal or can usually be ignited with a match, thus decreasing the amount of smoke and annoyance. The stirring will have a tendency to cool the mixture slightly and where the nature of the mould requires the use of a very hot bullet metal it is well to increase the flame under the pot, where this is possible, when fluxing.

It is desirable to have a tin box at hand in which to drop the dross or oxides skimmed off but, as a matter of fact, any small box of wood or tin will serve.

Bullet Casting Procedure.

Now that we have all the materials at hand they should be arranged conveniently and the pot containing the bullet metal put over the fire to melt. If gas is used it should be turned up full till the metal is completely melted, after which the heat can be reduced as desired. The mould may be rested on the stove or placed close to the flame so as to heat up the block, but should not be allowed to get hot enough to burn any oil or grease that may be in the cavity.

When the metal is melted, put the ladle into it and allow it to heat. Then dip up some metal in the ladle, place the spout in a horizontal position against the pouring hole in the sprue cutter and turn both mould and dipper to a vertical position. Hold them in this position for a second or two. Remove the ladle, leaving some metal in the sprue hole. When the mould and metal are at the right temperature it will require a second or two for this excess metal to solidify but when first starting, the metal may solidify almost instantly due to the mould being too cold. The first bullets are apt to be misshapen affairs for the same reason. If the bullet metal is not hot enough it will solidify before completely filling the mould cavity. On the other hand, if the mould is too cold it will chill the metal before it has time to fill the
189 cavity. When the mould and bullet metal are at the proper temperature it will require a second or two for the excess metal in the sprue hole to solidify after the ladle is removed. When the mould and metal are at such a temperature and the bullets do not fill out completely, it is usually due to mould blocks that fit too tightly together and do not permit the air to escape from some part of the cavity.

When the sprue has solidified the sprue cutter should be struck squarely with the stick and swung to one side, after which the mould may be opened over the pad, allowing the bullet to drop out. If the bullet does not drop out of its own accord, rap the side of the mould joint slightly

with the stick of wood to jar the bullet out. *Never strike a mould with a hammer or other metal object.*

If the first bullets are not perfect, continue to cast them; they will get better and better as the mould warms up and you will shortly get perfect ones. As long as any oil or grease remains in the mould cavity the bullets will not fill up or they will be covered with small pits from the tiny gas bubbles formed when the hot metal comes into contact with the oil.

Breaking in a New Mould.

Most mould blocks are made of malleable or alloy iron and come already blued or oxidized, so require no breaking in. If a mould cavity is bright it will not cast good bullets until the surface of the metal becomes oxidized. The ordinary procedure in such a case is to use the mould until the heat transmitted by the bullet metal accomplishes the desired result. This is often a long and tedious process and the job can be greatly hastened by placing the mould blocks on the top of a hot stove or by holding them near a gas flame until the cavity turns to a dark straw or blue. Before attempting to blue a mould cavity the mould should be washed in gasolene or carbon tetrachloride to remove all the oil, as the slushing oil used as a protection against rusting may carbonize and burn onto the mould. This will make blotchy bullets but the offend- 189
ing carbon can usually be removed by rubbing with a soft cloth over the end of a wooden stick. It is a good plan to wash out any new mould, or any mould that has been oiled, before attempting to cast bullets with it. But if gasolene is used it should be outside of any room where there is an open flame. Gasolene is far more dangerous stuff than any kind of powder and the fumes carried to a flame by air currents have been responsible for many bad fires and fatal explosions.

Block Alignment. Contrary to popular belief a bullet mould is a precision implement and it must be used with reasonable care if it is to give long and satisfactory service. We all like to cast bullets with as much dispatch as possible but a little care in opening and closing the mould will not slow up the casting of good bullets to any appre-
ciable extent and it will prolong the life of the bullet mould.

Most of the bullet moulds made today are of the so-called loose block type. The essential parts of one of these moulds are shown in the illustration on Plate XIV. Each half of the mould block contains half of the mould cavity. This cavity is cut with a special reamer called a cherry which is made the exact shape of the bullet and no change can be made in the shape of the standard bullets, for which the manufacturers cut moulds, without making a new cherry which is an expensive job. However, some manufacturers will cut moulds for bullets that are longer or shorter than the standard, where the design of the cherry will permit.

The fit of the dowel pins on one block into the holes in the other block governs the alignment of the two halves of the cavity. When used properly there is very little wear on the holes or the pins but if the mould is yanked open and slammed shut, the holes will become burred at
the edges and enlarged, which will throw the two halves of the block out of alignment and make it impossible to
190 get perfect bullets from the mould. This looseness in the two halves of the block is known as "shuck" and can usually only be eliminated by returning the mould to the factory, having the holes reamed out larger and new dowel pins fitted.

Sprue Cutter Adjustment. The "sprue" cutter is a flat steel plate attached to the top of the mould block by a screw. The under surface of this plate fits closely against the flat top surface of the mould and forms the flat base of the bullet. The sprue cutter has a beveled hole in it, the bevel coming to a knife edge at the under side of the plate. This hole is the orifice through which the molten metal is poured into the mould and it is positioned approximately over the center of the cavity by a stop pin. The bevel of the pouring hole accommodates the dipper or the spout of the ladle, and the edge cuts off the "sprue" or overflow of metal after it solidifies.

The tension on the pivot screw of the sprue cutter should be sufficient to hold the cutter in firm aligning contact with the top of the block and if this screw becomes loose, metal is apt to flow in between the surface of the block and the bottom of the sprue cutter, forming a fin on the base of the bullet. If such a fin forms with the pivot screw reasonably tight, it is an indication that the sprue cutter is sprung and directions for attempting to overcome this condition are given elsewhere in this book. The stick of wood referred to above is necessary for striking the sprue cutter to cut off the sprue. Its size and shape are not important and any stick handy to use is all that is needed. A piece of old broom handle is excellent. *Neither the sprue cutter nor any part of the mould should ever be struck with a metal object.*

Corrosion of Moulds. Next to the individual who uses a bullet mould with more brawn than brains, the worst enemy of moulds is rust. Their oxidized film resists rust but will not prevent it. If you use your moulds frequently they can be put away with the last bullet left in
191 them without opening the mould; that is, you can pour the mould full and leave it that way. This will exclude atmospheric moisture fairly well for a reasonable period of time under ordinary conditions but will not serve well where the humidity is high. When moulds are not to be used for a considerable period of time they should be oiled or greased. The grease or oil should be wiped off before using the mould again or, better still, washed off as already suggested.

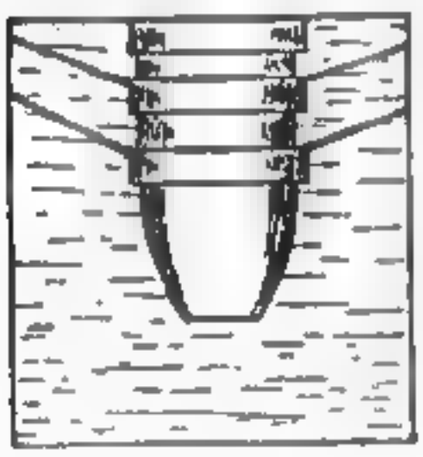
CASTING TROUBLES AND THEIR REMEDIES.

Failure of Bullets to Drop From the Mould. If the mould requires only slight jarring to make the bullets drop out, the condition can be ignored as a slight amount of "sticking" is unavoidable. The bullet usually persists in sticking in one certain half of the mould. Some operators tap the inside edge of that block with their stick—this is pretty apt to spring that half or cause it to warp open in time. Others tap the end of the handle

in which half the bullet is stuck—this is apt to split that handle in time, but it can readily be replaced.

If one has to resort to pounding to get the bullets out there is something wrong and the mould will probably have to be returned to the manufacturer to have the defect remedied. The slightest damage to the sharp edges of the mould cavity will form a burr that will hold the bullets in and only an experienced mechanic can remove such a burr without damage to the mould. The average individual should not tamper with mould cavities in any way. Any manufacturer will correct a new mould that is at fault without charge, so it seems foolish to take a chance on ruining a four or five dollar mould.

Failure of Bullets to Fill Out. This is usually due to the mould, the metal or both being too cold. If the mould is too cold the metal will solidify before it has time to flow into all the corners. The net result will be the same if the metal is not hot enough. Sometimes mould 192
blocks fit so closely together that the air cannot escape and with such a mould it is impossible to get good bullets unless the mould is "vented." Venting is done with a fine three-cornered file, with which shallow grooves are filed across the inside face of the mould blocks in such a way that the air may escape from the points where the bullet does not fill out properly. If the vents are filed too deep



An imperfect bullet and the venting necessary to correct the faults.

the bullet metal may flow into them when the mould and metal are very hot, but this does no harm as the projecting slivers will be sheared off when the bullet is sized. Venting can be done by anyone who is handy with a file but the file *may* slip and there is a good possibility that the file will burr the edge of the cavity. A vented mould is shown on this page which will serve better than a description of how the job is done. But remember—if a new mould does not cast good bullets the manufacturer will either vent it for you or replace it!

Bullets Out of Round. Due to shrinkage of some alloys when they cool, and to small manufacturing tolerances in the moulds, bullets may be a thousandth of an inch or so out of round as they come from the mould. They are purposely cast a little over size to permit truing them up in a sizing die of the correct diameter. If the variation in diameter is greater than two or three thousandths of an inch it may be due to a faulty mould, 193
burred or enlarged dowel pin holes or to the presence of specks of lead on the inside faces of the mould blocks. Sometimes when dropping a defective bullet from the mould into the melting pot, lead will splash upward and small drops get caught between the mould blocks. These flatten when the mould is closed but hold the blocks apart enough to cause the bullets to be out of round. Such lead flakes are easily removed with a sharp knife.

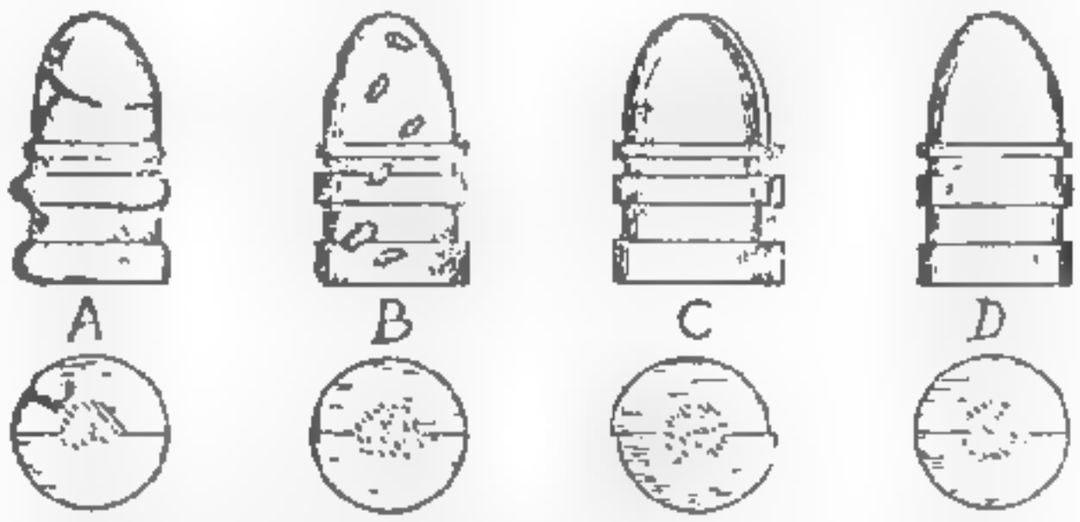
Fins on Bullets. Mould blocks do not fit together properly or sprue cutter is not flat against top of mould blocks. If sprue cutter is loose tighten the pivot screw. If the sprue cutter is bent, remove it and try to straighten it with a light hammer. Then file the under surface flat, put it back on the mould and try it. If you cannot correct the difficulty in this way you will have to get a new sprue cutter. Burrs or raised metal around the dowel pin holes can be detected with a straight edge, they are easily removed with a flat file, but care should be taken not to file across any part of the mould cavity.

Failure of Two Halves of the Mould Cavity to Coincide. The dowel pin holes are enlarged and the mould will have to be returned to the factory.

Frosted Bullets. When bullet metal cools it shows under the microscope as a crystalline formation. The size of the crystals depends upon the rate of cooling. If the metal cools quickly the crystals are small; if it cools slowly they are large. Bullets that solidify quickly in the mould will, therefore, usually have a bright shiny appearance but where the mould and the bullet metal are very hot and the metal cools slowly, the crystals will be so large that the bullet will have a frosted appearance. This difference in crystal size does no harm and has no affect on the performance of the bullet. If the mould and metal are allowed to cool down a little it will disappear but it must be borne in mind that some bullets with narrow bands, and especially bullets with hollow points and hollow bases, 194
must oftentimes be cast with somewhat hotter metal than normal.

Folds and Seams. Either the mould or the metal is too cool.

Lead Smears On Top Surface of Mould Blocks. Usually caused by striking off the sprue when the mould



A—Bullet not filled out. Metal or mould too cold. B. Effect of grease or oil in mould. C. Two halves of bullet do not match. Mould has excessive "smuck". D, Perfect Bullet.

is very hot and before the metal solidifies. This lead can usually be removed with a sharp knife when the mould is cold. It can also be removed with mercury. Be careful not to damage the edge of the cavity when you go to scraping around it with a sharp knife.

Elliptical or Lop-sided Bases. Generally confined to very soft bullets and caused by the base of the bullet

being forced to one side when the sprue cutter is struck. See that the cutting edge of the cutter is sharp. It can be sharpened with a counter-sink turned with the fingers. If a soft alloy is used this defect can be reduced by closing the sprue cutter just far enough to allow the metal to be poured.

Hollows In Base of Bullet. These occur in bullets that are cast with a very hot mould and metal. The more slowly a bullet cools the coarser the grain structure will be and the more chance of the metal breaking off at 195
the sprue. This leaves little crystalized depressions in the bullet bases. They do no harm other than to slightly reduce the weights of the bullets and only affect the accuracy to the extent that the weight of the bullet affects it.

Manufacture of Bullet Moulds.

Bullet moulds are ordinarily made from blocks of malleable iron. These blocks are machined to the proper shape and size and the interior surfaces carefully ground so that they will fit perfectly together. The two halves of the mould are then clamped together and are drilled through at the proper points for the dowel pins and the corresponding holes in which the dowels are to fit. This insures perfect alignment of the two halves of the mould. A hole is then drilled in such a way that half of it is in each half of the mould block. After this the two halves of the block are brought together against a revolving cherry which is a special form of reamer that cuts a cavity the exact shape of the bullet. This sounds like a simple process and so it is to tell it on paper, but the operation is one calling for special skill and experience.

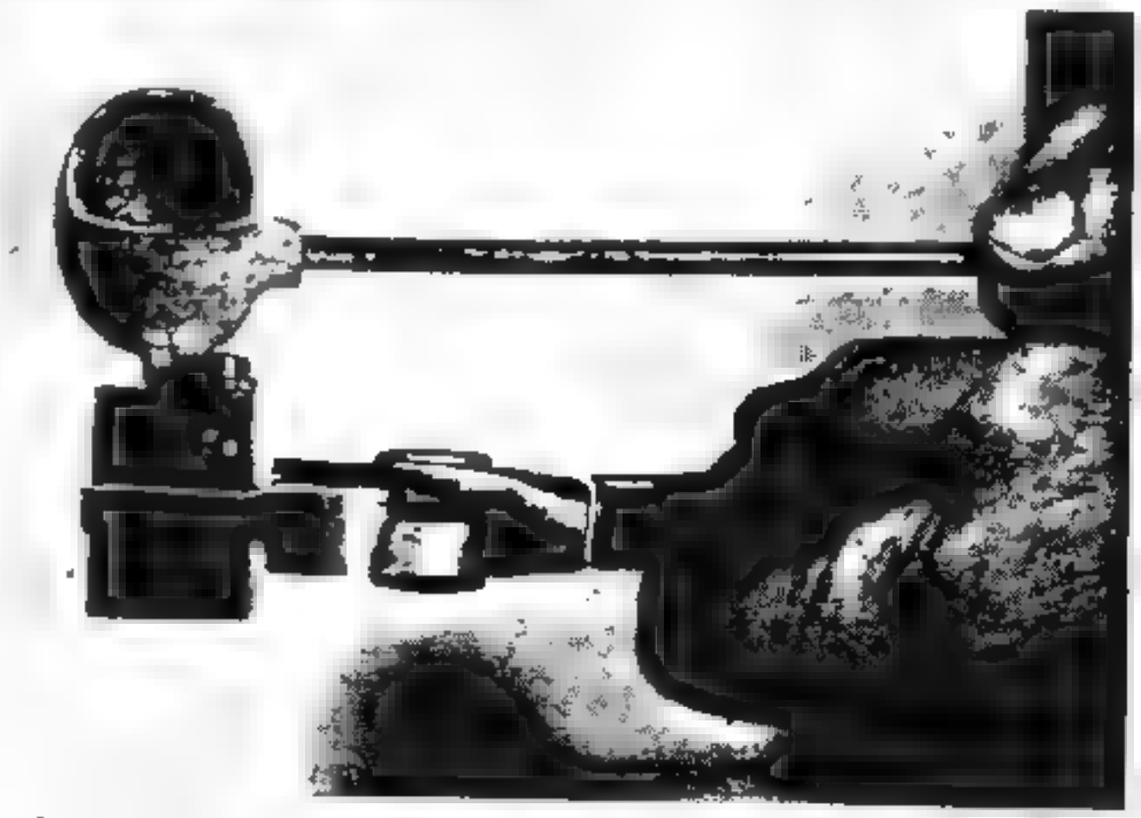
In the first place, a cherry is one of the most difficult reamers to make and frequently a lot of "fussing" is necessary before a new one will cut right. In making a cherry the stock is turned and ground to the shape of the bullet and to a size that will cut a cavity of the proper size. Ordinarily a cherry will not cut a cavity quite as large as itself unless allowed to run for an excessive length of time, and allowance must be made for this as well as for a possible shrinkage of the bullet alloy used. After the cherry is shaped the grooves must be milled in it longitudinally after which the real hard work begins for the tool maker. Merely cutting the grooves in the cherry will not leave it in condition so that it will cut, the ridges must be backed off before the cherry will cut, as the cutting edges or faces must always be the widest parts of the projections. This "backing off" is all careful hand work and the amount that the edges are backed off depends 196
upon the kind of metal the cherry is to be used on. For example, a cherry made for cutting cavities in malleable iron would not be satisfactory for use in steel or bronze and sometimes a cherry must be worked over several times before it will cut smoothly and without chattering. Even if the clearance is correct a cherry will chatter at times. If this happens when the cavity is nearly finished, both faces of the blocks must be reground and the cavity recut or the blocks may be cherried out for a larger caliber of bullet.

The older type bullet moulds had no detachable blocks, each half of the block being integral with one of the handles. The oldest ones had no dowel pins, but they were in general satisfactory. The objection to this type of mould was largely a manufacturing one for it was necessary to carefully fit the mould blocks before they were cherried and if anything went wrong with the cherrying the entire mould had to be scrapped. Furthermore, there was a tendency for the castings to warp under the influence of heat, throwing the two halves of the mould out of alignment. However, in spite of this many of these old moulds, including those that have no dowel pins, are still in satisfactory condition after years of use.

With detachable blocks, cherrying is more uniform from one mould to another than it used to be with the old style solid block moulds. The latter, being hinged and closing on an arc, had a tendency to squeeze the cherry away from the hinge and when this happened there wasn't much to do but pitch the mould in the creek. Nevertheless, most of the old style moulds that finally got out of the factory were pretty good and some of them were excellent.

Hard spots in the blocks make trouble and blow holes in the castings may cause uneven cutting and necessitate recherrying. It is not possible by ordinary production methods to cut two cavities *exactly* alike except by chance but the differences between cavities cut with the same

Usual "set-up" for proper casting of bullets over the gas-range.



Method of casting necessary to get perfect and full bullets.

PLATE XV.

cherry are small indeed. In moulds having more than 197
one cavity (for same bullet) the bullets will often be of different weights. When bullets of different weights are fired they will not shoot with the same elevation, that is, the heavier ones will shoot a little higher than the light ones. The difference can not ordinarily be detected by ordinary shooting but the reloader who wishes to get the most uniform results should use bullets from one cavity; it doesn't matter which one.

Mould Repairs and Adjustments.

As has been stated, when a mould does not perform properly, the best bet is to return it to the manufacturer for correction. There is not much that can be done with the old solid block moulds. If a cavity is slightly burred, it may be possible to correct it if the present cherry is exactly the same shape as the one with which the cavity was originally cut, but recherrying these old moulds is likely to ruin them. Moulds of this type in common use are mostly Ideal moulds, made by the Ideal Manufacturing Co., by the Marlin Firearms Co., of New Haven, Conn., or by the Lyman Gun Sight Corp. when they first started making Ideal reloading tools. All the old fixtures for cherrying these moulds have been scrapped which makes recherrying them of uncertain outcome and the Lyman Co., will not do any work on these moulds except at the risk of the owner. Thus far they have been lucky, probably because they will not undertake such a job unless they are fairly sure that it can be done right.

The detachable mould blocks can be recherried at small expense either for the same bullet for which they were originally made or for a larger caliber bullet, provided the larger bullet is enough bigger and longer so that the original cavity can be entirely eliminated. It is not possible to recut a mould for a different shape of bullet of the same or nearly the same caliber.

It sometimes happens that a reloader is so situated that he cannot conveniently return his mould to the factory and an attempt will be made to suggest simple ways in 198
which a cantankerous mould may be improved or a rusted or damaged one can be made serviceable. It should be understood that work of this kind had best be done by a skilled mechanic and the novice who tries it with poor results will have to take the responsibility, as no manufacturer will correct a mould that has been tampered with, without charge.

Venting. Probably the most troublesome condition in a new mould is the failure of bullets to fill out properly. Hollow point and hollow base moulds are particular offenders, as the hollow point or base plugs cool more rapidly than the rest of the mould and have a tendency to cool the metal before it can flow into the narrow space left around these parts. Venting, hot metal and rapid casting will at least partly overcome this trouble. Failure of any bullet to fill out is caused by failure of the air to escape from part of the mould before the metal solidifies. It may be due to the metal not being hot enough or to the two halves of the block fitting too closely together. Bullets with narrow bands are special offenders.

An old trick for correcting this, and one that has some virtue, is to put a strip of thin paper between the two halves of the mould. This will make a slight gap between the halves for the air to escape through but it will also put the bullet slightly out of round. As a matter of fact, cavities often run a thousandth of an inch or so out of round and this is one of the reasons for making the moulds a bit over size so the bullets can be trued up by sizing them to the correct diameter later.

The best remedy is venting and to do a really good job of venting a small, fine cut, three cornered file should be purchased and prepared for use in the following manner:

If the file has blank places near the end, grind the end back far enough so that there is cutting surfaces only on all sides. Then grind one side of the file flat and smooth. This will bring two edges down so the cuts on the other
199 sides will come down to sharp, fine teeth. If an emery wheel is used, the file should be plunged into water fre-

Leading Problems.
The bullet on left is not well filled out. Its rounded edges would give a different degree of leading (if any) than the same bullet with sharp bands. Bullet on right has too large a nose for the barrel it was fired in. Such a long unlubricated bearing often causes leading.

Failures near the heads of factory loaded cartridges These were caused by hidden defects in the brass. New cases are not a guaranty of safety when loading maximum loads not even with loads of normal pressures.

PLATE XVI.

quently while grinding so that the heat will not destroy the temper.

Examine some of the imperfect bullets carefully and note at just what part of the bullet the air is being imprisoned; then with the file carefully file shallow grooves from the corners of the cavity that form the *bands* of the bullet. These grooves should run all the way across the faces of the mould blocks. It is not necessary to make the grooves very deep and it is best to try the mould from time to time and stop filing when the bullets come out perfect.

Sprue Adjustment. Another trouble is in the smearing of lead across the top surface of the mould and the formation of a fin of lead at the bullet base. This may be due to a sprue cutter that had been sprung by striking it in an upward direction in which straightening it as described before will correct the fault. But there is another cause. In spite of everything that has been said and published about it for the past half century or more, some fools will persist in hammering moulds with metal objects that are harder than the mould blocks instead of with a stick of wood, in order to jar the bullets out. This can not help but burr the edges of the mould block and if the burr occurs at the top edge of the block, the sprue cutter will ride up on top of the burr, leaving a space between it and the top of the block into which metal can flow. Under such circumstances the bullets will surely have fins on their bases. If you are having trouble from fins on the bases of your bullets and suspect you are one of the misguided souls referred to, push the sprue cutter out of the way and lay a straight edge across the top of the mould at right angles to the joint line, then move it across the top surface from front to rear. If there is a high spot on the edge of the block you will be able to see light under the straight edge. The remedy is to file off the burr, but in doing so do not file across the top of 200
the cavity. It is only necessary to remove the burr, not the top of the block. This will correct the trouble if the sprue cutter is not also sprung, in which case that will have to be straightened also by using a light hammer and surface plate. After all this has been done, get a stick of wood to tap the mould with.

Lapping the Cavity. Some moulds drop their bullets very nicely when opened, but they are in the minority. The average mould requires a little tapping to jar the bullets out and as long as a *little* tapping is all that is necessary, it is best to leave the mould alone. However, it is a fact that some moulds have to be pounded to get the bullets out of them. This is bad, both for the mould and the disposition of the moulder—and should be corrected. The bullet form may have a lot to do with it as bullets with flat ends or square grooves will always stick more or less. With other shapes of bullets, sticking is due to a slight burr on the edge of the mould cavity. It may be a very minute burr or feather edge but it doesn't take much to keep a bullet from dropping out. This condition can be remedied by lapping.

Cast a bullet and when it is cool, cut a groove around it where the joint line, or the mark left by the joint between the two halves of the mould, comes. Then drill a hole in the base of the bullet, as near the center as possible, and put the bullet back in the mould cavity so the groove in the bullet is at the joint line. Screw a wood screw into the hole in the base of the bullet *with your fingers.* If you use a screwdriver you may expand the base of the bullet and then that will be the only point which would bear on the cavity when the mould is closed. Now twist the bullet around in the cavity, gradually increasing the pressure of the mould handles until the bullet can be rotated with the fingers with the mould closed. The reason for cutting away the joint line is, that if this is not done a ridge of lead is liable to be pinched up be-
200 tween the halves of the mould and the bullet can not be rotated nor the mould closed tight.

Next, remove the bullet with the screw still in it and dip it in some flour of emery and oil or valve grinding compound; it doesn't matter whether the latter is fine or course. Put the bullet back into the cavity but don't close the mould tight enough to prevent your turning the bullet around with your *fingers.* Gradually increase the pressure on the handles again until the mould is apparently closed, then, open it, wipe off all the muck that has squeezed in between the blocks and repeat the process until you can turn the bullet with the mould fully closed. Why do I emphasize using the fingers to turn the bullet? Because it is only necessary to remove a little feather edge on the cavity and you don't want to remove any metal from the cavity itself, as that will enlarge it. This is a simple operation *but a delicate one* so don't put the end of the screw in a breast drill and grind for five minutes or so. A few turns of the bullet and lapping compound with your fingers will do the trick very nicely.

Rusted Blocks and Cavities. The above procedure can be used in cleaning out a cavity that has rusted. If the inside surfaces of the block are rusty, moisten them with oil or nitro solvent and go over the surfaces carefully with the flat edge of a screwdriver or a small scraper. You can easily remove the rust from the flat surfaces in this manner. If there is only a small spot of rust or two in the cavity you can best rub them out with a little abrasive on the end of a pine stick but if the rusting is bad, lapping with a bullet will have to be resorted to. It takes very little lapping to remove rust. After you have lapped a mould, wash it in gasoline to remove the lapping compound that may remain in the cavity.

If the mould cavity has been badly rusted and pitted, the bullets will have blotches on them. These will do no particular harm, but the pits may be rough enough to cause the bullets to stick. If, after you have lapped a rusty mould,
202 the bullets do stick in the cavity so as to require undue pounding to get them out, prepare another bullet by cutting away the joint line and drilling it. Then put a little oil on it and stick it into some powdered graphite and proceed just as if you were lapping the cavity again, only this time don't wash the cavity out. The graphite will pack into the pits and will remain there quite a while, as heat will have no effect on it and it will not adhere to the bullets. You will be surprised how nicely bullets will come out of an

apparently worthless mould when it has been treated in this manner.

Misalignment of Blocks. Fins along the joint line of the mould are due to failure of the blocks to come together properly. The mould blocks are made of soft iron and the dowel pins which align the two halves of the block are of steel. If a mould is yanked open and slammed shut, as they often are by the gentry who are imbued with the idea that nothing connected with handloading is any good unless it can be done fast, a burr will be thrown up around the dowel pin holes which will prevent the two halves of the block from coming together. This is also the cause of some bullets being out of round, although a very slight eccentricity of bullets as cast is common and is one of the reasons for casting them over size, then trueing them up to the correct diameter later. Burrs around the dowel pin holes can be removed by filing them. *Do not rub the file across the cavity* and work slowly, with a sharp, fine-cut file.

Unfortunately, the improper use of a mould not only results in setting up burrs around the dowel pin holes but it enlarges the holes, causing a condition known as "shuck", or an angular alignment of the halves of the block. There is no remedy for shuck except to return the mould to the factory. The pins must be removed, all the holes lined up and reamed out larger, and new and larger dowels fitted and this is no job for a novice without special equipment.

Chapter Seven

BULLET LUBRICANTS.

The function of a bullet lubricant, like any other bearing lubricant, is to provide a moving film between the bullet and the barrel, while the former is passing through the bore. If this is accomplished, it makes no difference what material is used for lubrication. Most of the waxes, or so-called waxes, make good bullet lubricant just as they are, but some of them have faults of a physical nature which prevents their convenient use without mixing them with certain of the softer greases.

If bullets are lubricated before they are sized, either by dipping or immersing them in melted lubricant, they must be cut out of the grease or the excess must be cut off with a cylindrical tube (the so-called kake kutter) that has an inside diameter about the same as the bullet, or slightly larger and which, when passed down over the bullet will cut or push off the excess lubricant. Some of the harder waxes do not adhere well to the smooth bullets and the fingers, which are usually sticky when doing this job, are apt to provide a more adhesive surface than the bullet and pick the lubricant out of its grooves. For this reason it is generally advisable to mix the waxes with a sufficient amount of softer grease until the mixture, in its cold state, is slightly tacky.

There is another factor that makes it necessary to soften the waxes; namely, the mechanical lubricators and sizers that are used by the majority of handloaders. These machines and their operation have been described elsewhere but in principle they provide a grease reservoir which communicates with the exterior of a perforated die. While the bullet is in the die, pressure is applied to the lubricant which is forced through the holes in the die into the grooves on the bullet. None of these machines are strong enough to handle hard waxes without excessive strain and wear. This strain with some waxes is sufficient to break the machine and with many of them the machines will quickly wear out. Lubricants for them should be of a consistency that can be forced through the machine with reasonable ease. This consistency will depend upon climatic conditions and in a cold climate a greater amount of softening agent will be required in the lubricant than in a warm climate.

The commercial lubricants sold by the manufacturers of reloading tools are all quite satisfactory and any of them will serve the needs of the reloader who does not wish to go to the bother of making his own. However, the ingredients from which these lubricants are made will not always be of a uniform consistency and the formulas have to be changed from time to time in order that the mixture may be soft enough to force through the mechanical lubricating presses.

I am very much afraid that the loading tool manufacturers pay more attention to the consistency of the lubricant than they do to the lubricating properties of the stuff that they make it from. Fortunately, they cannot go very far wrong because it is hardly possible to mix up a combination of waxes, fats or greases that will not lubricate bullets. We have already seen that the design of the bullet and the displacement of metal which takes place when the bullet is going through the barrel have a material affect upon leading, and leading can be translated into an absence or inefficiency of lubrication. Therefore, the best lubricant it might be possible to mix would not necessarily prevent leading with an improperly designed bullet or one of improper diameter for its barrel. We have also seen that the velocity at which a bullet is driven has a great deal to do with its leading. It is well to bear in mind that any increase in velocity in the bullet obtained by an increase in powder charge will also result in increased heat.

We must also consider that many bullets have broad bands and that part of the ogive or bullet nose as well as the forward band must come into contact with the barrel before the first lubrication groove can do its work. This does not mean that such bullets are not good bullets, but it does mean that the forward part of the bullet must depend largely on the lubrication that is left in the barrel by the previous shot. This is especially true of bullets having a cylindrical forward portion that is supposed to *ride* on top of the lands and center the bullets—but which often bear hard on one side and not at all on the other.

The amount of lubricant that remains as a coating on the bore after a shot is fired will depend upon the character and fit of the bullet and the heat developed by the powder charge. Of the materials ordinarily used for bullet lubricating purposes, very little is known of their relative lubricating properties because they are not ordinarily used as commercial lubricants and there has been little or no

incentive to make any exhaustive study of them as lubricants. They will, however, all burn, so the amount of residual lubricant left in a barrel after a shot has been fired will depend upon the shape, dimensions and hardness of the bullet, the friction between it and the barrel, and the heat developed by the powder charge.

Anything that can be used for a bullet lubricant will burn and burn at a much lower temperature than it is subjected to in the barrel of a firearm. However, the time during which it is subjected to this intense heat is so short that there is normally more or less of it left in its original state on the interior of the bore. If entirely consumed, the residue, being carbonaceous and devoid of lubricating properties, may easily contribute to the leading 206
of the barrel. Personally, I do not believe that the heat developed by any revolver loads is sufficient to burn much of the lubricant that may be left in the barrel. It may happen in rifles with the heavier gas-check bullet loads but while I have gotten leading in some guns that I can only attribute to combustion of the residual lubricant, I have been unable to prove definitely that this was the cause. When jacketed bullets are lubricated and fired at high velocities, there is a distinct trace of smoke that follows the bullet for some distance. The heat of the bullet is responsible for this and this heat comes both from friction and the gasses. If the heat of the bullet is sufficient to cause decomposition of the lubricant, the heat at the interior surface of the barrel certainly must be hot enough to do this also. Without wasting more time and space with conjectures over this possible and plausible, but questionable detail, it can be stated definitely that it is worth while changing lubricants when leading pokes its unwelcome snoot into the picture. This is especially recommended where a barrel suddenly leads with a load that has previously been satisfactory.

Slivers of lead imbedded in the lubricant on bullets are suspected of contributing to the leading of barrels and especially revolver barrels. Some sizing dies shear off slivers of lead from the sides of the bullets and these slivers are often seen adhering to the sticky lubricant in the grooves of bullets. Leading from this suspected cause results from the slivers being blown out of the bullet grooves and into the barrel, after which they are ironed onto the bore by the passing bullet. As particles of lead are also blown from the edges of the base and bands of the bullet it is impossible to state just how much of the leading can be blamed onto the slivers. In any event, leading from this cause alone is not of much consequence and seldom causes inaccuracy. The slivers themselves, being lubricated, are usually easy to remove.

Of the materials most suitable for making bullet lu- 207
bricant for reloading purposes the following are the most common; Japan wax, carnauba wax, beeswax, ozokerite, cerasine wax, tallow, paraffin, petroleum jelly or vaseline, and automobile cup greases of which there are a variety. Vaseline and cup grease are related and because of their softness are best used as softening agents for the harder waxes. The first five waxes are all excellent bases for bullet lubricant but all of them are too hard to work through the lubricating and sizing machines unless they are softened by the addition of other substances.

A brief description of these and a few other commonly available materials follows:

Ozokerite. Ozokerite or earth wax, as it is commonly called, is a mineral wax that is dug out of the ground. It is a sort of crude paraffin and varies in color from a light to a very dark brown. In its natural state, it varies greatly in consistency also, being found in some places as a soft wax and in others as a dense hard substance. Ozokerite forms the base of most of the commercial lubricants of a brown color that are sold for reloading purposes. Its natural differences in hardness are reflected in the consistency of the refined wax and it is necessary to vary the quantity of softening agents used with it according to the hardness of the particular lot of ozokerite that one gets. The melting point varies widely with the consistency or from 58°C. to 100°C. Presumably the combustion point varies as well and I have known a ripple of complaints of leading to follow the distribution of a new lot of lubricant made from this substance.

Cerasine Wax. Cerasine is ozokerite refined by drastic treatment which clarifies it considerably and renders it from a light yellow color to nearly white. It is closely related to paraffin and, like it, lacks the tackyness to make it stick in the bullet grooves. It varies in consistency and the amount of softening material used with it must be varied also. Cerasine is commonly used as an
208 adulterant for beeswax and is sometimes colored and sold as beeswax or as beeswax substitute. It is a good lubricant and there is nothing to worry about if you happen to get cerasine wax when you think you are getting beeswax. The melting point varies between 61°C. and 78°C., which is not as wide a spread as its parent, ozokerite.

Cerasine wax is the lubricant used on Filmkote and Kleenkote .22 Long Rifle bullets. Being one of the most inert if not the most inert wax there is, it does not have much tendency to pick up grit. These bullets are lubricated by a process patented by Mr. Pedersen, the designer of the .276 Pedersen automatic rifle that was under test by the Ordnance Department a few years ago. In general the process consists of dissolving the proper amount of cerasine wax in heated carbon tetrachloride and with the solution held at the exact temperature necessary, the bullets are dipped. The time they remain in the solution is very important for if removed too quickly, the coating of wax will not only be too heavy but it will chip off easily. It is quite a trick to do even with the proper temperature control and entirely impracticable without special facilities. When the bullets are removed from the solution, the tetrachloride volatilizes out leaving a thin and almost imperceptible film of wax on the bullet.

The Pedersen automatic rifle operated on the delayed blow-back principle and did not function too well with dry cartridge cases, especially if the cases were hard and did not stretch much, as the setback of the case was necessary to good functioning. As a dry case normally grips the chamber walls, Mr. Pedersen developed this method for lubricating the entire cartridge with cerasine. The thin

coating left by his process was not noticeable, did not pick up dirt readily and the chamber heat caused the wax to melt, affording perfect lubrication and certain functioning. The use of this wax in such a thin coating on Cal. .22 bullets offers a good example of its excellent lubricating properties.

Heel-Ball. This is the black, waxy residue obtained 209
from the refinement of cerasine and it is ordinarily used to give a polished finish to the heels of shoes. It is obtainable in almost any community but whether or not it is any good for bullet lubricant I do not know as I have never been driven to the extreme of using it. As it is really the dregs of ozokerite, I suspect that its lubricating properties are limited.

Carnauba Wax. This is a vegetable wax obtained from a species of palm tree found in Brazil and some other tropical countries. It is dark in color, almost black, and quite hard. Its lubricating properties are good. The melting point varies between 72.5° and 85°C. Carnauba wax, because of its hardness and the lack of a tendency to pick up grit, makes a good lubricant for outside lubricated bullets.

Beeswax. This wax is too well known to require description here. It makes a good bullet lubricant and is obtainable almost everywhere. Although beeswax is often adulterated with cerasine, this makes no difference as cerasine is excellent as a lubricant. Beeswax is "stickier" than cerasine wax and requires less softening than the latter to make it stick to the bullets. The melting point of unadulterated beeswax is 67.2°C. A time honored bullet lubricant can be made from beeswax, by adding enough machine oil to make it the desired consistency. The machine oil should be kept to the minimum necessary to do this, as in the hot sun there is a tendency for the oil to exude and it may seep down into the powder if there is an excess present.

Japan Wax. This is a vegetable wax obtained from an oriental tree and it is an excellent bullet lubricant. It runs fairly uniform in consistency with a melting point from 55° to 60°C. The specifications for the U. S. Cal. .30 gallery practice cartridge, which was loaded with a lead alloy bullet, called for pure Japan wax as the bullet lubricant and it has also been used by the commercial ammunition manufacturers for lubricating lead bullets. 210
The pure wax is too hard to work through the Bond and Ideal lubricators and sizers but it can be softened with vaseline or sperm oil.

Tallow. Tallow is an animal fat with excellent lubricating properties but, in common with other animal fats, it is liable to become rancid in warm climates. It varies in consistency and is so soft that it can seldom be used as a softening agent for the waxes except in cold climates. Its melting point is from 42.5°C to 46°C., which is only a little over 100°F. and ammunition often attains this temperature when exposed to the sun in temperate and tropical climates. Under the influence of warmth, tallow liquifies and the resultant ooze is liable to work down into the powder and primer. But in this respect, tallow should not be compared with oil as a softener for the waxes. Tallow is a solid at ordinary living temperatures while oil is a liquid and consequently, oil is much quicker to exude under the influence of heat than tallow. Put a piece of tallow on a sheet of paper where it is exposed to the rays of the sun and in a short time there will be a grease spot on the paper but a drop of oil will permeate the paper at once. Tallow is better than oil for a softener, except under conditions where it is likely to go rancid.

Paraffin. Paraffin is a white mineral wax of good lubricating properties and is related to ozokerite and cerasine. Like all mineral waxes, paraffin does not have the tendency to stick to bullets like some of the true waxes have. The use of paraffin is indicated where a bullet lubricating mixture is too soft and sticky. A small amount of it added to the mixture will harden it and reduce the tackyness. Melting point 55°C.

Petroleum Jelly. Otherwise known as vaseline. It is of the same general chemical composition as paraffin but much softer and is one of the best substances for softening waxes. Being a mineral product, it will not turn rancid,
211 it has good lubricating properties and, as its melting point is fairly high, it is not so likely to exude into the powder charge as is mineral oil.

Machine Oil. A mineral oil related to the mineral waxes and may be used sparingly with them as a softener. It combines better with them than with animal or vegetable waxes. Being normally a liquid, there is a tendency for mineral oil to seep out of bullet lubricant under the influence of warmth and this is especially true if the lubricant has a vegetable or animal wax base. Being of mineral origin, it combines better with the mineral waxes.

Castor Oil. This is a well known lubricating oil of vegetable origin and can be used as a softener for the vegetable waxes, but tallow or vaseline are cheaper and work very well.

Sperm Oil. Real sperm oil is in reality a true wax in spite of its name and liquid form. Its excellent lubricating properties are well known and it serves well as a softener for the animal waxes. But much of the so called sperm oil on the market is either adulterated or is a downright substitution of a certain kind of fish oil. It can be relied upon to be the real thing only when purchased from a reliable dealer. However, it doesn't make much difference whether it is pure or not for, when oil of any kind is used as a softener, only a small amount is required. It is the wax base of the lubricant that does most of the business, so there is not much object in being too fussy about the oil when the latter is used as a softener.

Graphite. Graphite is neither a wax nor a grease but it is a good lubricant if used judiciously. Flake graphite is not suitable for use in bullet lubricant and the finest powdered form available should be used and used sparingly. Ten per cent by volume added to the lubricant is sufficient and an excess should be avoided, as too much will build up in lumps in the barrel. The graphite should be stirred into the melted lubricant and the stirring continued until the mixture cools, to prevent the graphite
212 from settling to the bottom. This method of mixing will

not always result in an even distribution of graphite through the mass and it is better to work the cold lubricant with a fork. Putting it through a meat chopper several times has also been recommended but I suggest the fork, if you want to remain on good terms with the cook. Graphite lubricant can only be used satisfactorily in a lubricating and sizing press. If it is melted, the graphite will settle to the bottom. The effect of the graphite, if it happens to work properly, is to leave a thin coating on the inside of the bore and as it will stand very high temperatures, there is no danger of its burning off. It should not be understood from this that graphite in the lubricant will certainly prevent leading and—if it is not used correctly, its questionable benefits will not offset the mess and bother of making it.

Factory lead bullets are often tumbled in graphite and pick up a thin surface coating of it, this probably helps somewhat to prevent these bullets from leading. About the best that can be expected from a lubricant containing graphite is, that the coating it may leave in the bore will about equal the light coating that is on the factory bullets. As long as there is a film between the bullet and the barrel, it makes little difference whether it is on the bullet or the barrel.

Colloidal Graphite. This is a substance that has appeared on the market quite recently. It is merely graphite which is so finely divided that it remains in suspension in the vehicle with which it is mixed. Lubricants containing this are much superior to those made with the ordinary powdered graphites, as the colloidal graphite will remain in suspension even when the lubricant is melted. In fact, even when the lubricant is liquified or cut with a suitable solvent, only a very small percentage of the graphite will settle to the bottom of a test tube. Aside from its colloidal nature, colloidal graphite is still graphite and should be used with discretion. An excess should be avoided.

Mixing Bullet Lubricants. 213

In discussing the various materials suitable for bullet lubricants, no attempt has been made to give specific formulas or mixtures. It is impracticable to do so as so much depends upon the consistency of the ingredients used. It is a simple matter to mix bullet lubricants. Melt the wax first and add a *small* amount of softener. Mix the mess thoroughly and pour a small amount onto a plate or other cold surface and let it cool well. Then scrape it off the plate and work it in your fingers. If it is too hard when you try to work it, or if it is slippery and does not stick to your fingers, add more softener and repeat the process. If it is too soft and sticky, add more wax. Remember that the hardness of a lubricant depends upon the way it is worked and the more you work it, the softer it will become, up to a certain limit, of course. But a lubricant that seems to be quite hard when you touch it after it has cooled, may be rather soft after it is worked. Squeezing the lubricant through the holes in a lubricator die works it considerably and you must make allowances for this when mixing the ingredients. A lubricant that may seem to be just right to the touch, once it has cooled will probably be too soft after it is forced through the lubricator. The whole business is a case of "cut and try."

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Chapter Eight

BULLET SIZING AND LUBRICATION.

Bullets and their sizing and lubrication are subjects so closely related to one another that it is impossible to consider them separately. Consequently, there is some overlapping of these subjects that can not be avoided, especially when lead alloy bullets are involved.

Jacketed bullets, as made in the United States, require no lubrication nor do they have to be sized in any way as they are made correctly for the cartridges they are intended to be used in. The .303 British service bullet which uses a cupro-nicked jacket, has a shallow groove filled with lubricant, the groove being covered by the case neck.

Some seventeen or eighteen years ago when our own military rifle shooting was all done with the old Model 1906 cartridge, loaded with a cupro-nickel bullet, riflemen used to lubricate the bullets externally. The cupro-nickel jackets, at velocities of over 2,000 f. s., left a thin deposit of metal fouling along the muzzle end of the bore for about 6 inches. This fouling would build up in lumps and streaks, impairing the accuracy of the arm until it was cleaned out and the cleaning was a troublesome process. Someone got the idea that lubricant on the bullets would prevent this metal fouling. A rifle was taken out on the range and fired a limited number of rounds with bullets that were dipped in and thinly coated with Mo-
215 bilubricant, a heavy automobile grease. The rifle did not metal-foul as might normally have been expected and without more ado Mobilubricant was hailed as a panacea for metal fouling.

For several years one couldn't find a rifleman on the line without his little tin box of Mobilubricant in front of him. For slow fire the bullets were dipped one at a time and for rapid fire the bullets of all the cartridges in the clip were greased before they went into the magazine or the belt. But during this period, the Ordnance Department began to get an increasing number of rifles with cracked bolt lugs or worse. Investigation finally disclosed that the Mobilubricant was causing the trouble. The greased bullets, rubbing against the hot chamber left grease in the chamber, or resting in the hot barrel for several seconds before firing, the grease melted and the excess leaked back into the chamber.

A cartridge case under normal conditions grips the walls of the chamber when the cartridge is fired but with lubricant in the chamber there was no grip and the case was driven violently back against the bolt face with more force than a rifle bolt is made to stand. As some shooters put great gobs of grease on their bullets, it is probable that in some instances the grease filled practically all the normal clearance between the cartridge, reducing the expansion of the cases and causing higher pressures than usual. In any event, a thorough investigation was made of the virtues of external lubricant on jacketed bullets and it was found that it really had little or no affect on metal fouling. Proper publicity was given this, as well as to the dan-

gers of lubricant in chambers, and the practice disappeared as promptly as it sprung up.

The method of measuring chamber pressures in small arms in Great Britain utilizes the set-back of lubricated cartridge cases, the copper crushers occupying a place between the head of the cartridge case and the face of the bolt of the special guns made for this purpose.

However, the practice of lubricating jacketed bullets is passé and is entirely unnecessary with gilding metal bullets anyway. Cast bullets when loaded in old black powder arms, with one or more lubrication grooves exposed, should be loaded into the chamber carefully to avoid greasing the chamber walls. The margin of safety of some of the older arms is not too wide, even with black powder loads.

Lead or lead alloy bullets cannot be fired with accuracy unless they are lubricated. If unlubricated, or if the lubricant is not of the proper nature, lead will rub off on the inside of the barrel and destroy its accuracy until cleaned out. For this reason, cast bullets are provided with grooves to carry lubricant, and these grooves must be filled in one way or another before the bullets are fit for use.

A bullet, as it comes from a mould, will probably contain some little irregularities. Most moulds cast bullets a few thousandths of an inch over size to allow enough surplus metal so the bullets can be trued up perfectly round and to the correct diameter by forcing them through a die of suitable size.

The best way to size and lubricate bullets is with either the Bond or Ideal bullet lubricating and sizing presses. They are both of the same general design, operate the same way, and do equally good work. Any reloader will do well to equip himself with one or the other of these little machines, especially one who does a considerable amount of reloading.

But bullets *can* be sized and lubricated perfectly by two separate operations. The bullets are *first* lubricated and then forced through a resizing die. All of the reloading tool manufacturers can furnish bullet sizing dies that are either used as attachments for their reloading tools or separately.

Many of the older Ideal Tools have bullet sizing holes through the handles, through which the bullets are intended to be forced point first. Unfortunately, this usually 217
does more harm than good to the bullets, as the excess metal is forced back and sometimes makes ragged bases on the bullets. Furthermore, the bullets are apt to tip as they come out, which further deforms the bases. This type of construction has been discontinued but, if you have such a tool, good results can be obtained by forcing the bullets through the hole *base first*. This will probably result in some slight deformation of the bullet point from the pressure of the plunger, but this is by far the lesser of the two evils. A better remedy is to get a bullet sizing chamber for the tool if it is of the adjustable type, or one of the several bullet sizing tools on the market.

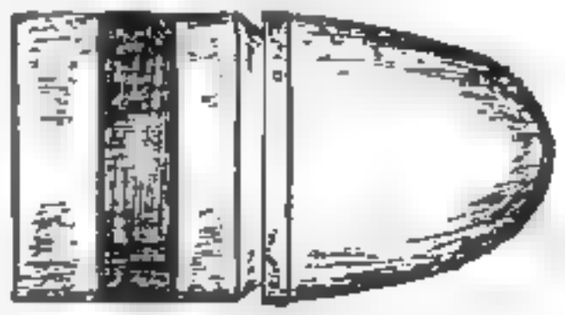
There are two simple, if somewhat messy, ways of lubricating bullets. The first and oldest method is to stand 216
the unsized bullets on their bases in a shallow box or dish and pour melted lubricant around them to a depth that will cover all the grooves. After the lubricant solidifies, the bullets may be cut out with a "kake kutter," which is a name given to a cartridge case with the head cut off or bored out and the mouth sized slightly larger than the bullet diameter. Any tubular article of suitable size, through which the bullets can pass freely, will do. The bullets are picked up by the kake kutter as it is pressed down over the bullets one after the other, the preceding bullets being forced up and out the top. As each bullet is forced out, take it with the fingers and set it down carefully, so the base will not be damaged.

This will leave your bullets in a condition that can be best described as a gooey mess, but they should not be wiped off. The next step is to force them through your bullet sizing die. This will size them and help to force the grease into the grooves. It will also scrape off much of the excess lubricant. In handling the bullets, try to avoid picking them up where the lubricating grooves are located. The lubricant is liable to adhere to your sticky fingers better than it does to the smooth surface of the lubricating
218 grooves. After the bullets are sized the surplus lubricant can be wiped from the bases and points of the bullets. They should then be packed neatly in small cardboard boxes so they cannot tumble about and damage their square bases.

Bullets can also be lubricated by holding them with the fingers and dipping them, one at a time, into melted lubricant, then standing them on their bases on a sheet of paper or tin. The lubricant will coagulate on the cool bullet and the excess is cut off with a kake kutter as described above. This is the best method of the two; it is quicker and possibly a bit cleaner.

There are a few bullets that have bands of different diameters that are not intended to be sized. The Belding & Mull, Squibb-Miller, and Ideal Pope bullets are notable examples of this type. These bullets must be lubricated by hand as just described.

Were it not for the leading which will result from the use of dry bullets, the problem of reloading ammunition would be greatly simplified; therefore, the subjects of bullet alloys and bullet lubricants are closely related, and a word about the distribution of the lubricant on the bullet will not be out of place here.



The idea of lubrication is to have a film of lubricant between the surfaces where friction is likely to occur. Many bullets are poorly designed with respect to the location of the lubrication groove or grooves, and many of them, especially revolver and pistol bullets, have only one wide groove. The drawing on this page is typical of such bullets, and shows how more than 50% of the bearing

surface of the bullet must come into contact with the
barrel before any lubricant in the groove becomes effective. The lubrication of the forward part of a bullet of this kind is dependent upon the lubricant left in the barrel from the preceding shot, and the amount and virtue of this residual lubricant will depend upon the composition and consistency of the lubricant used, as well as the bullet alloy.

Use of Grease or Wax Wads.

The practice of using a wad of wax, or wax softened slightly with grease, under the bases of bullets, either with or without a card wad between them and the powder, is as old as breech loading arms. The practice has had a recent revival and it is claimed that the use of colloidal graphite in the wads has some particular virtue in preventing leading in revolvers and reducing erosion in some rifles. Perhaps it has, but the practice of using fusible wads of any kind behind bullets should be approached with caution.

As has been explained elsewhere in this book, there is every indication that the neck of a cartridge case expands before the bullet moves forward to seal the bore and that a certain amount of gas escapes between the case neck and the bullet. This is a normal condition and the escapage of gas influences the chamber pressure. If the case neck and the chamber are such a close fit that there is no expansion of the neck and no escapage of gas past the bullet, the pressure developed by the charge will be materially higher than normal. This is the condition found in special tight chambers.

When a wax wad is used under a bullet, the density of loading is increased, if the bullet be seated to its normal or prescribed depth, which, if not influenced in any other way, will cause some rise in pressure. If the clearance between the expanded case neck and the bullet be small, the melted wax will seal the space, just as oil in an engine cylinder seals the gas from passing the piston. This will cause a considerable increase in the chamber pressure and create a condition analogous with that of the tight chamber. Therefore, if a fusible wad is used under a bullet, I would suggest in the interest of safety that the thickness of the wad be considered as part of the seating depth of the bullet and that any full charge of powder be reduced at least two grains in weight, just as when loading cartridges for tight chambers. This applies especially to the newer cartridges such as the .257 Roberts and the .220 Swift, as these calibers have a closer relation between case necks and chambers than some of the older calibers. I also believe that any reduction in erosion obtained from the use of grease wads is due to their effect in preventing the gasses from rushing past the bullet plus possibly some lubricating effect between the unburned powder grains and the barrel.

Where there is several thousandths of an inch between the expanded neck of the case and the bullet during the cycle of combustion, or when the clearance is great enough to permit the melted wax or grease to be blown past the bullet, the increase in pressure will not be so great but unless the clearance be considerable, there will be more or less increase. We can compare the effect of a grease base wad in a tight chamber with a normal automobile cylinder in which the oil seals the gas above the piston and the normal chamber with an automobile that pumps oil. The difference in both cases is purely that of the amount of clearance between the moving metal surfaces.

The effect that these grease base wads have on pressures can only be determined with a pressure gauge but the effect on lubrication can easily be seen by anyone interested enough to make a simple experiment.

Any normal military rifle is all right for making the test which is as follows: Cast up some bullets of any alloy but do not lubricate them. Load ten of them, dry, with a moderate charge of powder and fire them. Ten will be enough to give the barrel a nice dose of lead. Push a dry patch through the bore to remove the surface powder fouling and any loose bits of lead and observe the condition of the bore so you will have a good mental picture of it for later comparison. Then, scrub as much lead out as possible with a dry brass bristle brush, plug the chamber tightly with a cork or wooden plug and load the barrel with metallic mercury to remove the remaining lead. There will probably be from six to ten inches of it and it must be completely removed. Incidentally, if the arm is ordinarily used with lead bullets it should be doped with mercury before you start the test. Thoroughness and uniform conditions are necessary if the results are to be of any value at all.

When all the lead in the barrel is amalgamated and the bore wipes out clean, repeat the process exactly as before *except* that the bullets must be seated on top of wads of wax or grease. Anything that you use for bullet lubricant will do and the wads do not have to be of any exact thickness. I suggest a thickness of from 1/32 to 1/16 inch. The results you get this time will depend upon the amount of powder used and may vary from no leading at all to a fair amount for a short distance, starting a couple of inches ahead of the chamber. The heavier the charge, the farther the leading will extend along the barrel and the more it will build up but with a light or moderate powder charge it will not amount to much and most, if not all of it, will come out with a little wire brushing. Always wipe the bore with a dry patch before examining it, as otherwise you may mistake powder fouling or other corruption for leading. The point is that some of the grease from base wads does blow past the bullet under the circumstances mentioned and lubricates the bore ahead of the bullet.

A few points to observe are: to wash all oil from the bore before firing each test; wipe the bore with a dry patch before examining it; use bullets from the same lot, and if the charge is a light one, use cases that have been expanded by previous firing without sizing the necks. The bullets can be held in good enough by crimping.

Because of the gas-check effect that the grease has in a tight chamber, their use can be considered as dangerous with heavy loads.

In revolvers, the use of a grease wad under the bullet is not so serious as there is usually plenty of expansion

of cases in such arms. If over sized bullets are used the situation may be changed, as the whole idea depends upon the clearance between case and bullet and may be very different in two different calibers or even two arms of the same make and caliber.

Grease or wax wads should be of a fairly hard consistency and should remain solid at any ordinary temperatures under which they are likely to be used. Otherwise, they may melt and run down into the powder charge, preventing all or part of it from burning properly. There is some indication that the powder which comes in contact with grease wads does not burn but that is getting into someone else's thunder, which is out of my line.

Making Grease Wads. These wads can be made from any bullet lubricant that is normally satisfactory for lubricating bullets in the usual manner. The only advantage that one substance will have over another will be in its intrinsic lubricating properties, as it will function in the same way whatever it is made of. If the wads are to be cut out and handled separately, they will have to be a little harder than ordinary bullet lubricant. They can be made by dipping a bottle or glass plate into the melted lubricant and removing it quickly. The wax will coagulate on the cold surface, leaving a coating that can be stripped off before it sets up hard. If the mixture is too soft, you won't be able to get it off the glass in a sheet. After it hardens, the wads can be cut out with a wad-cutter made from a cartridge case with the head cut off and the mouth sharpened a little by beveling it with a knife. Wads made in this way are usually very thin and for thicker ones, the melted lubricant can be poured onto a glass plate. Grease 223
wads are most easily and nicely handled by leaving the lubricant on the glass. After the cases are charged, the mouths of the cases can be pressed *up* against the plate and slid off, each case cutting its own wad perfectly. In seating the bullets, the bases should not go in far enough to push the wad back into the body of a bottle neck case for, if the wad fails to stick to the bullet base, it will be ineffective. Seating them that deep is inadvisable anyway.

Bullet Sizing.

Now, about sizing bullets; most of that has been gone over under the subject of "Bullets" but bullets are lubricated to prevent leading and the way they are sized has much to do with this. Many of the newer bullet moulds, especially those for rifle bullets, drop their bullets so large that they can not be sized down to a proper diameter without nearly obliterating the lubrication grooves. One of the things that you will observe, if you try that little leading experiment just mentioned is, that at low velocities, there is very little tendency for a bullet to lead a barrel once it is fully impressed into the rifling; it has reached a point where the base is no longer expanding and is only sliding along through the bore. And this with a dry bullet too! As the velocity is increased, there is an additional thrust against the driving edges of the lands and the leading is carried farther up the barrel. As the velocity increases the leading increases and the higher the velocity the more important proper lubrication becomes.

Let us suppose that we have one of these gosh awful Cal. .30 bullets that casts about .316" to be sized to .311" which is .003" too large for most Cal. .30 barrels. Sized to .311" it carries a fair amount of lubricant as we look at it, but when fired the lands not only cause lead to be displaced back over the lubrication grooves but the whole surface of the bullet must be swaged back as well. We can't size the damned things down to .308" if the bullet has a gas-check as trying to
224 force a .311" gas-check through a .308" die will bust the lubricator. If we could, we would see the grooves considerably decreased in width and made more shallow. Narrow grooves would practically be wiped out. Whether the sizing is done in a die before the bullet is loaded or afterward in the barrel, the net result is the same.

If one of these bullets is driven at a high velocity, the lubrication that it carries may hold out till it gets to the end of a 24" barrel but be insufficient to take it out of a 30" barrel. Actual tests have shown such bullets to lead six inches of a long barrel enough to destroy the accuracy, but by reducing the velocity considerably they would get all the way through without leading. Which comes right back to the effect of velocity on leading.

Somewhere else I have referred to the edges of the bases and bands of bullets being blown off by gas rushing past the bullet before it moves up into the rifling. (See "Revolver Cartridges".) The same thing happens to rifle bullets in normal chambers and, it is reasonable to suppose, a certain amount of lubrication is blown out of the grooves at the same time. In a rifle, all of this lubrication is blown into the barrel but in a revolver it is not and more or less of it escapes between the barrel and cylinder. After firing the latter arm a dense, greasy residue is always found plastered around the rear end of the barrel. This means less lubricant on the surface of the bullet, where it is most needed. The heavier the powder charge, the more lubricant blown out of the grooves and just when the bullet needs it most because of the higher velocity. Revolver bullets should not be sized large enough to fit the throats of their chambers and consequently, there is no way to check this loss. It gives no trouble with properly designed bullets at normal velocities.

Now let's see if we can briefly gather together in a concrete resume some of the scattered generalities about sizing bullets, here where they will be available for ready reference.

225 1. Cast bullets for rifles should be sized to not less than the groove diameter of the barrel they are to be fired in, and those for revolvers should be so-called standard diameters or the diameters of factory bullets of the same caliber—unless there is some very definite reason for doing other-
[redacted]

2. The ability to size bullets to their proper diameter is limited by the design of the bullet and its size as it comes from the mould. Many moulds cast bullets that are entirely too large. If these bullets are sized down to the normal groove diameter of the barrel of their caliber they may size off center and the lubrication grooves will be decreased in width and depth to a point that may easily cause leading.

3. The exact method or tool used for sizing bullets is not important except; that they should never be sized point first. When sized base first, the die or tool should have a recess that will receive the bullet as cast and *center* it over the reducing part of the die. Top punches of lubricating and sizing tools or of sizing tools and chambers *should fit the points of the bullets properly.*

4. The apparent off-center sizing of bullets is more often due to a slight excentricity in the bullet as cast rather than to lack of alignment of the sizing die and punch.

5. There may be a tolerance of about .0005" from the diameter marked on a bullet sizing die. This tolerance is almost always on the plus side and is of no practical consequence.

Things to remember:—

That the size of a cast bullet has an effect on leading in addition to the amount and kind of lubricant used, the velocity at which the bullet is driven, the heat and pressure developed behind the bullet, the tolerance in the neck of the chamber and the amount of gas that escapes past the bullet before it moves into the rifling, the melting point of the bullet alloy and the hardness of the bullet.

The more the diameter of a bullet exceeds the groove 226
diameter of the barrel it is fired in, the more apt it is to lead the barrel. The reverse seems to be true with some bullets in revolvers but this is due to the lesser reduction of the lubricating surface of the larger bullet plus a smaller escape of gas past it due to its filling the throat of the chamber better. This sometimes has a beneficial effect in a short revolver but seldom in a rifle barrel. However, the causes of leading are so many and so interdependant that no hard and fast rule can be laid down.

Bullets can not be arbitrarily sized smaller to reduce leading. Everything depends on the design of the bullet and whether its as-cast dimensions will permit the reduction in size.

Chapter Nine 227

MECHANICAL POWDER MEASURES.

The Ideal, Bond and Belding & Mull powder measures are very convenient and useful devices for measuring powder charges rapidly and with sufficient accuracy for any purpose excepting long range target shooting and for maximum charges. The method of using these measures is described in the literature of their respective manufacturers so there is no need of repeating that here, but it is pertinent to explain the principles underlying their operation and their limitations.

The Bond and Ideal measures work on much the same principle. They have powder reservoirs, below which are rotating parts that can be adjusted to provide a measuring cavity of variable capacity, the cavity being adjusted according to the kind and volume of powder desired. The measuring devices are provided with graduations that serve as reference marks for setting the measures and the manufacturers furnish tables by means of which their measures may be set for any desired charge of any kind of powder.

The Belding & Mull measure differs from the others in its operation, although it is the same in principle. It has a measuring device that takes the form of an adjustable cup or measure entirely separate from the rest of the apparatus. The capacity of the measure proper can be adjusted for the charge desired and after it is charged, the powder is dumped into the cartridge case with the aid of a funnel.
228 This is somewhat similar to the old-fashioned dip measure, but is much more accurate and convenient.

The two questions that arise in regard to mechanical powder measures are, how accurately may they be set by their graduations and, how uniform will the charges be thrown after the measures are set? There is no definite answer to either question. Much depends upon the way the measure is operated, the kind of powder, the quantity used in each charge and the shape and dimensions of the measuring cavity. If the measure be not operated smoothly and uniformly, the charges can not be uniform, although with the most careless operation of any of these measures, the charges thrown will not vary more than those found in the ordinary run of factory ammunition.

The kind of powder makes a difference in the uniformity, because some powders have smaller grains than others and consequently flow more smoothly. Coarse grained powders do not measure as uniformly as the finer grained ones. Even the humidity affects the way the powder flows and as a general rule, powder will not flow as smoothly in damp as in dry weather, even though the moisture in the air has no effect on the burning of the powder after it is loaded, at least no effect that the reloader can detect.

The shape of the cavity also affects the uniformity of charges. If one were to select a certain kind and charge of powder and adjust all three measures to throw the same weight, it might be found that one measure seemed to measure that charge a little more uniformly than the other two, but if the kind of powder were changed and the measures set for a greater or smaller volume, the advantage would very likely switch to one of the other measures. A noteworthy example of the effect of the dimensions of the measuring cavity on the uniformity of powder charges is found in the Ideal Micrometer Powder Measure. This measure has one rather thick measuring slide, by means of which the cavity size is governed. The depth from front to rear and from top to bottom of the cavity is fixed by the
229 width and thickness of the slide. The width of the cavity is controlled by the amount that the slide is drawn out. When this measure is set for small charges of pistol powders, the cavity is so narrow that the powder can not flow into it uniformly and used in this way the variations in the weights of successive charges are greater than are considered permissible, therefore the manufacturer does not recommend this measure for use with pistol powders. The Ideal Universal Powder Measure provides a broad, shallow cavity for pistol powders and handles these charges very nicely.

Assuming that we have one or another of these measures, let's look at the successive steps in setting and using it in order to get the most uniform results, for the accuracy of the ammunition will depend more upon the uniformity of the successive charges thrown than on the precise weight

of the charge.

Powder Measure Graduations and Settings.

Bond and Ideal Powder measures are graduated in grains weight of Black Powder, but in using them with smokeless powder the graduations should be considered merely as arbitrary reference lines. The Belding & Mull measure has arbitrary graduations that have no particular relation to any one kind of powder. This is just as good a system and perhaps better than trying to tie the graduations up with *one* kind of powder. I think that this idea of trying to explain and reconcile black powder graduations with the settings for smokeless powders is one of the most confusing things ever put forth for the beginner at reloading and I would suggest that anyone not loading black powder forget all about the black powder graduations on the first two measures mentioned. As a matter of fact, all the different granulations of black powder bulk differently in a measuring cavity of any given volume and charges of fine grained black powder will be heavier than charges of coarse grained black powder when measured in the same volume, which doesn't make any difference as Black Powder should be measured by VOLUME and *not* by WEIGHT.

The principle of any of these mechanical powder measures 230
is simple and satisfactory. They all have adjustable measuring cavities. They all measure by VOLUME and *not* by weight. The larger the cavity is made, the larger the volume of the charge it will measure and consequently the greater the weight of the charge. Tables for setting the measures are furnished with them. In all of these tables there is a column for each kind of powder. To measure any charge, select the column representing the kind of powder you are going to load, select the weight of charge you want, and set the measure on the graduation indicated by the table for that weight and kind of powder. That's all there is to it.

The graduations on powder measures are evenly spaced and doubling the number of graduations of the setting will double the volume and the weight of the charge, regardless of the kind of powder used. Powder measure tables are usually computed on this basis, the results being checked by setting the measure at different volumes and actually measuring and weighing the charges thrown. The *average* weight of several charges is the weight shown in the table for the particular setting given.

Due to the difference in densities of different lots of the same kinds of powders, mechanical powder measures can only be depended upon to throw *approximately* the weight of charge desired when set according to a fixed table. Actually, the charge may be slightly lighter or heavier than is indicated by the table, but it will not be enough different to worry about as long as it does not exceed a normal full charge. Maximum charges should never be measured; they must be weighed. Where it is desired to get the greatest degree of accuracy of charge, scales or balances must be used, but the mechanical powder measures will, when used properly, throw charges with all the uniformity necessary for extreme accuracy with all but the coarsest grained powders. Even with coarse grained powders they do surprisingly well if the ammunition is judged by its performance rather than the mental contortions of a novice handloader who has been 231
misguided into believing that any powder charge that varies more than one tenth of a grain in weight is inaccurate. No one can be criticized at all for taking all the pains and time necessary to get uniform charges of powder into reloaded ammunition, but the average reloader has an exaggerated idea of the degree of uniformity necessary to get first class accuracy. Our present day factory ammunition is pretty fine stuff, but how do you suppose the powder charges are loaded. By weighing? Not by a dawgone sight! They are measured by volume, in gravity powder measuring devices that work very much on the same principle as the measures used by handloaders. The latter, however, has a little the advantage because he can take more time and care with his loading and by careful use of a mechanical measure, can get a greater uniformity of charge than is possible on a loading machine. Naturally, the question arises as to how to use a powder measure to get this extra accuracy. Granting that the nature of the powder, as well as the very principle of bulk measurement, imposes some limitations on the accuracy that can be obtained with certainty, any mechanical powder measure is subject to certain conditions and if these are observed by the user, he will get all the accuracy and uniformity of charges that his powder measure is capable of.

Hints on the Use of Powder Measures.

The Ideal and Bond Powder measures work on the same principle but the Belding & Mull measure is a little different. We will consider the first two together and the latter by itself.

When powder is emptied from a canister into the reservoir of a powder measure, the grains fall in a hap-hazard manner and the powder column is "loose" and of an uneven density. If the measure is used with the powder in this condition, the jarring incidental to the operation of the measure will cause the powder to settle and increase in density and the charges will increase in weight, from one to another, until the powder reaches its maximum density. By maximum
232 density is meant that the powder has settled as much as it possibly can.

Therefore, after emptying powder into a measure, the measure should be tapped or jarred until the powder will settle no further, before the measure is used to load any ammunition. But jarring the powder column to its maximum density is not enough to insure uniform charges from the

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Most of us have at some time in our lives played with a funnel and sand. When the funnel is filled with sand and the sand is allowed to flow out of the spout, the sand flows in toward the center, or directly over the outlet, forming a moving column down through the mass. The sand at the outside of the mass does not move down appreciably until the widening cone in the center reaches the sides of the funnel. In moving in this way, the sand particles slide one upon another and arrange themselves into what may well be called "lines of flow." If the sand be coarse and rough or if it be damp, it will not flow with the ease and freedom of fine, dry sand.

Powder works the same way in a powder measure. True, it does not flow unrestricted through an opening in the bottom of the measure, but its principle movement down-

ward is through the measuring cavity and after a varying number of charges have been thrown, lines of flow are established in the powder just as they are in sand when passed through a funnel. With a measure set for a small charge of pistol powder, it may be necessary to throw quite a considerable number of charges before the lines of flow are established, while dumping only a few heavy rifle charges may do the trick. Once these lines of flow are established, the powder will measure at its maximum uniformity. The coarseness of the grains, the character of the grain surfaces and, to a lesser extent, the moisture in the atmosphere, will affect the uniformity of the flow; fine, smooth powders will always flow smoother and consequently measure more uniformly than those with coarse or rough grains and there is nothing that anyone can do about it— 233
unless it is to weigh them.

To summarize: the proper way to adjust a powder measure is to put the powder in, filling the hopper or reservoir nearly to the top and then tap or jar the measure, settling the powder until it will settle no further. Then, with the cover off, throw enough charges rapidly into any suitable box or container so that a depression begins to form in the upper surface of the powder, over the measuring cavity. It is immaterial whether the measuring cavity be adjusted before or after the powder is put in. The powder that has been taken from the measure in doing all this can be dumped in on top without affecting the charges.

It is commonly recommended that the powder measure be kept at least half full of powder so that the charges will be uniform and not be affected by the reduced or greater weight of the powder column. Well—that won't do a bit of harm, but is surprising how little difference the weight of the powder column makes with the charges thrown. With the lines of flow established, the charges will run uniform until the powder in the reservoir of the measure is nearly exhausted. Once the measure is in operation, loose powder added will not affect the charges, unless the powder level be very low. Try it sometime. In fact, if reloaders would do a bit of experimenting to see how *little* difference some things like this make, instead of letting their imagination run wild over theoretical details, they would load a lot more and better ammunition and get much more enjoyment out of doing it.

The Belding & Mull powder measure has two reservoirs and a detachable measuring device. The operation of the measure is such that when the operating lever is pushed over, a quantity of powder passes from the upper reservoir to the lower one and loose powder from the lower one flows into the measuring device. The powder available for charging the cartridge is always loose and it is claimed that this makes for greater uniformity of charges. It certainly provides a uniform condition from one charge to another and 234
possibly offers some slight advantage as compared with the Bond and Ideal measures, provided these last mentioned measures are used improperly. I have used them all, and have used them correctly, and I honestly can see no advantage in any one over the others that is of practical consequence. As previously mentioned, one or the other of them may show a little better uniformity with certain charges and powders, but they are all equally good and I mean, good when they are used with proper care. Charges of some powders can be thrown with any of them to such close limits that there is absolutely no need of, nor advantage to be gained by using a scale. Scales are useful for setting any of these mechanical measures to throw *exactly* the charge desired, provided that the scales are as accurate as the measure. Scales are a necessity for weighing maximum charges, as these charges are dangerous in that they encroach considerably upon the factor of safety of arms and allow little or no leeway for ordinary variations on the plus side. There are so many other things that can cause pressures to rise besides the powder, that the use of maximum loads can not be recommended; at least they should only be used by reloaders who know more about ammunition than just weighing powder charges to a small fraction of a grain. However, when these overloads *are* used it behooves one to use every care with the powder charges. That at least is one step in the right direction.

In operating a powder measure, one should be methodical. The handle should be raised and lowered uniformly, both as to the force employed and the time. This is not important with the Belding & Mull measure, but it is with the Ideal and Bond measures if one wishes to get the finest degree of accuracy that these measures are capable of. The little knocker on the Ideal measure should be flipped the same each time but it is immaterial whether it be flipped hard or easy, so long as it is done uniformly. Leave the operating lever down after throwing a charge. Time is a
235 factor in the way that the powder settles in the measuring cavity and if this cavity is exposed to the powder in the reservoir for varying periods of time, the powder will settle a whisker more one time than another. If the handle is left down between charges, raised to the charging position and held there for about a second and the charge then emptied; and this procedure kept even and uniform, the best accuracy will be obtained. Naturally, the powder measure should be used on a table or bench that is free from vibration. Powder measures that are mounted on reloading presses can not throw charges as uniformly as those that are divorced from any jar or vibration.

The moving parts of some measures will work very nicely if they are taken apart, oiled and as much of the oil as possible is wiped off with a dry cloth before they are put together again; but the use of oil can not be recommended as a general rule. Often the dust and fine particles of powder will adhere to the oily surfaces, building up in streaks and causing the measure to stick. This will sometimes happen with a measure that has never seen any oil. The best remedy is to put a box under the drop tube to catch the powder, then work the lever up and down, forcing it if necessary, until it works freely. This working will polish the surface of the powder that has been caught between the moving surfaces of the measure and its presence will prevent the entrance of additional powder dust. The thin flake pistol powders are particular offenders in this respect.

Bridging. Bridging is a condition that may occur with any mechanical powder measure where the powder must pass through a drop tube before it enters the mouth of the

cartridge case. It is obvious that any such tube must have an outlet orifice which is not larger than the caliber of the cartridge being loaded, although the opening may taper upward to a considerably larger diameter at the top. Sometimes, and especially with powders having coarse or long grains, the powder will drop from the measuring cavity in such a way that the grains will jam in the drop tube. This is known as "bridging" the grains; in effect, forming a 236
bridge across the inside of the drop tube. When this happens, only part of the charge drops into the case whereupon the succeeding charge usually dislodges the bridged powder, causing an overload in the next cartridge. This is a condition which has to be guarded against very carefully in factory loaded ammunition, bridging being by no means limited to the mechanical powder measures used by handloaders.

It is therefore desirable to have the inside diameter of drop tubes as large as possible, so as to avoid this condition. The Ideal and Bond measures use drop tubes and as they are used for all calibers of cartridges, it would be necessary to have the exit orifices in these tubes small enough for .22 caliber cartridges, if only one tube were available. Therefore, both manufacturers supply two different sizes; one handling .22 to .25 caliber cartridges and the other handling everything above .25 caliber. Bond furnishes both tubes as standard equipment with their measure but Ideal only furnishes one; the standard or larger tube, if no caliber is specified. However, the smaller size will be furnished with the measure if requested. The operator should always use the largest possible size for the cartridge being charged. As the .22 HiPower and many of the .25 caliber cartridges utilize some of the coarse grained powders, special care is necessary to prevent bridging when loading these calibers —which is just one of the many reasons for inspecting *all* powder charges before seating bullets.

Drop tubes fit into a counter-bored hole, against a shoulder in the body of the measure, and are held in place by set-screws. The jarring due to operation of the measure, may and often does cause this screw to loosen, permitting the drop tube to work down a little. This makes a gap between the outlet of the measure proper and the top of the drop tube. The top edge of the drop tube is too narrow to form much of a resting place for grains of the coarser powders, but it will catch some of the fine grained ones. It is, therefore, advisable to check the drop tube once in a 237
while to make sure it is firmly up against the shoulder in the measure and to be certain that the set-screw is holding it there tight.

The Ideal measure has a little swinging knocker on its front, which should be flipped up against the body of the measure to jar all the powder out of the tube. The Bond measure lacks this knocker, but the operating handle may be knocked against its stop several times to accomplish the same result. Neither measure should be jarred when their handles are in the upward or charging position, as this can not be done uniformly and will cause variations in the charges. Even with jarring, bridging will occur once in a while; also if the drop tube is not up into its seat fully the amount of fine grained powder that catches on top of it may not be dislodged completely each time.

The Belding and Mull powder measure uses no drop tube, but as the powder is fed into a separate charger so that the height of the charge is plainly visible before emptying it into the case, bridging is no factor in this measure. But drop tubes must be kept clean and clear and all measures watched closely in the interests of both accuracy and safety.

Factory Measuring Practices. Factory loaded cartridges are charged by three different means, all of which would be unsatisfactory without inspection of the charges after they are thrown.

One method is to "shake" the primed cases into a loading plate having a series of holes in rows, regularly spaced. This plate, filled with cases, is slid under the charger, the bottom of which is another plate with a similar series of holes bored on exactly the same centers as the plate holding the cases, these holes being beveled at the top. The upper holes are therefore directly over the mouths of the cases and are of a diameter smaller than the caliber of the cartridges being loaded, so that any powder falling through them will drop into the cases. On top of the upper plate
238 is still another, with a similar series of holes on the same centers; this is the charging plate and it can be slid back and forth by means of a lever. The thickness of this charging plate and the size of its holes governs the volume of the powder charges. When this charging plate is slid to one side, its holes are off-set from those in the plate it slides on and their bottoms are closed by the solid metal between the holes in the lower plate.

In operation, the operator throws a scoop full of powder across the charging plate, employing a sweeping motion so that the top is covered with powder and all of the holes are filled, after which the excess powder is scraped off with a rubber edged scraper. In doing this, powder is scraped over any holes which were not filled with the first "swipe." The charging plate is then slid over the holes and those charges drop down into the cases, the operator striking the apparatus a couple of good raps with a mallet to jar all the powder out of the holes. Naturally, the corner holes do not get quite as dense a dose of powder as the holes in the center of the plate, but the operators of this type of loading machine become quite clever at throwing the powder and the variations in the weights of the charges are not great, although they would give heart failure to some of these theorists who can think only in tenths of a grain. In a loading machine of this type there is no opportunity for bridging of the powder, or at least the chances of a bridged charge are very slight. Nevertheless, the cases are inspected as they are passed on to the next operation. This method of charging cases is in common use for pistol and revolver charges and occasionally for some rifle cartridges.

Another method is to use a plate holding a smaller number of cases, 7 x 7 being a convenient arrangement of holes. These plates locate the mouths of the cases under a series of tubes leading down from the mechanical measuring device at the bottom of the powder hopper. The tubes originate from points in the charging mechanism which are more widely separated than the cartridge cases, so they are not all

of the same length and some of them must curve consider- 239
ably in carrying the powder charges to the cases. The operator of the machine uses a substantial mallet to rap the steel block in which the tubes terminate, to jar the powder out. When the plate of charged cases is taken from the machine, a j.g or plate carrying a series of plungers, T shape in cross section, is placed over them so that a plunger will drop down into each case and rest upon its powder charge. The cases and plungers together are slid along to the next machine, but in so doing must pass through a template with profile cuts in it conforming roughly to the shapes of the plungers. The cross bar of the T in these plates is higher from top to bottom than the T heads of the plungers, so there can be a little variation in the heights of the charges and still let the cases and plungers pass through the slots. But if the variations in the height of even one charge in the block raises or lowers a plunger too much, the plate will not pass through the gate and the loading can not be completed until the offending charge or charges are corrected. Beautifully shooting ammunition is loaded by this method every day in the week, which makes it look as if it wasn't altogether necessary to fool around with tenths of a grain to get good accuracy.

The third type of loading machine is the one most similar to the powder measures used by handloaders of ammunition. This type utilizes a cavity in a sliding block, or a rotating member with an adjustable measuring cavity, which successively charges from a hopper and discharges into a cartridge. All the charges are measured by the one cavity. These machines are always equipped with mechanical or electrical detectors for checking the heights of the charges after they are emptied into the cases, and some of them will automatically throw out cases which are over or under charged. There is naturally an appreciable tolerance in the heights of charges and the function of visual or mechanical inspection of charges is for safety only. The check for finer degrees of accuracy in charges is accomplished by taking charged cases from the machines at intervals and weighing 240
their charges. It is common practice to weigh three charges at a time from each machine, and to take the average weight of those three charges as a check on the machine setting.

Any reloading tool or machine—past, present or future—that charges cartridge cases and which will not permit them to be inspected before the bullets are seated, is dangerous and not worth the powder to blow it to hell—no matter how ingenious it may be otherwise.

The Accuracy of Powder Charges.

Accuracy is a relative term. If we want to lie on our bellies and dump bullets into a ten inch bullseye two hundred yards away, our powder charges may vary as much as 5% in weight, without putting us out in the white and our ammunition is accurate. On the other hand, if we are in pursuit of the elusive one inch group at one hundred yards or the best accuracy we can get at a thousand yards, such a variation would make the ammunition inaccurate for our purpose. To generalize, pistol charges should be kept within a variation of 3% of the weight of the charge and rifle charges within 1%. These variations are satisfactory from a safety and accuracy standpoint, with charges up to and including normal full loads. If one is loading maximum charges, the variation should be kept as small as the Great Jehova and the Continental Congress will let it be. Mechanical measures, properly used, will keep most charges of powder well within the limits above mentioned but where the requirements are exacting an accurate scale or balance should be used.

Dip Measures.

The mechanical powder measures are by far the best for measuring any kind of powder charges with all the uniformity necessary for obtaining good accuracy. These measures are especially valuable for use with smokeless powders, as these powders are of such a nature that anything more than small variations in the weights of charges may cause
241 a considerable change in their behavior. This is particularly true with full loads for any cartridge, but the differences in burning caused by variations in the weights of charges decrease as the charges are reduced. One can have quite a little variation in the weights of reduced charges and still get pretty good accuracy up to two hundred yards or more and herein lies a boon to those who can not afford to pay from seven and a half to ten dollars for a powder measure.

Dip measures are perfectly practical for measuring black powder, as in loading black powder, the case must be filled up to the base of the bullet. There is therefore, no chance of loading an over-load with a dip measure. These dip measures are also satisfactory for use with semi-smokeless powder, provided that the proper granulation of powder is used and the scoop holds the weight of charge recommended. Scoops are not ordinarily recommended for use with smokeless powders, as the variations in weights of charges that will be obtained with a scoop are sufficient to cause dangerous pressures if full loads are used. If, however, the load is enough below a full charge, scooping smokeless charges is permissible and, with care, good results can be obtained.

Belding & Mull or Lyman will, on special order, make up powder scoops to hold any specified charge of any kind of smokeless powder, or one can make one of these for himself if he has a scale available to check the charge measured by the scoop. A fired cartridge case, cut off or filed down so it will hold the proper amount of powder, with a wire handle soldered on is all that is necessary. In ordering a dip measure for smokeless powder, you should at least specify the kind of powder, that is, the manufacturers designation of it, and the weight of charge desired. It is also well to state the caliber of cartridge and weight and kind of bullet that will be used. These scoops are, for the most part, ordered by those with little or no experience with reloading and if all the information is given, the manufacturer may be able to set you straight if you have selected
242 a powder unsuited for your purpose or an improper charge.

When you get one of these dip measures you will probably find the handle soldered onto the side about half way down; you can improve on this by re-soldering the handle near the top. This should also be done if you make your own dip measure. A combination of measure and dipping box that is very satisfactory and that will give you the most

satisfactory and uniform results you can get with a dip measure can be made in the following manner:

Properly made dip measure and dipping box.

Solder the handle on the scoop near the top and in such a way that the little gap between the side of the cup and the handle, where the latter bends away from the cup, may be filled with solder. The placement of the handle should be such that a straight edge may be drawn along the handle and across the top edge of the cup without catching. A dipping box can be made from any suitable container; a tin baking powder or simular can, cut off so it is about two or two and a half inches deep will do. Now, solder a strip of brass across the inside of the can, near the top, so that the brass strip will form a chord of the circle of the top of the can. The strip must be at least the diameter of the dip measure away from the side. This completes the apparatus.

To use it, pour enough powder into the can so that the scoop may be passed through it and filled without touching the can. A good way to fill the scoop uniformly is to press its base down into the powder until the powder flows over the edges of the scoop, filling it. When the scoop is buried, 243
raise it with the handle under the brass strip and draw the scoop toward you, scraping the powder off level with the top of the scoop. The slight jar of doing this may cause the powder to settle a trifle, but do not refill the scoop. What you want is uniform weights of charges, rather than uniform volume, and you won't get either if you do not do this dipping uniformly and systematically. You can dip charges much more uniformly with a box of this kind, than by holding the scoop in one hand and scraping it off level with a straight edge held in the other.

Some kind of a funnel will be needed to pour the powder into the cartridge cases. A convenient and inexpensive one made from a small aluminum funnel and a drop tube for a powder measure is described at the end of the section on "Powder Scales."

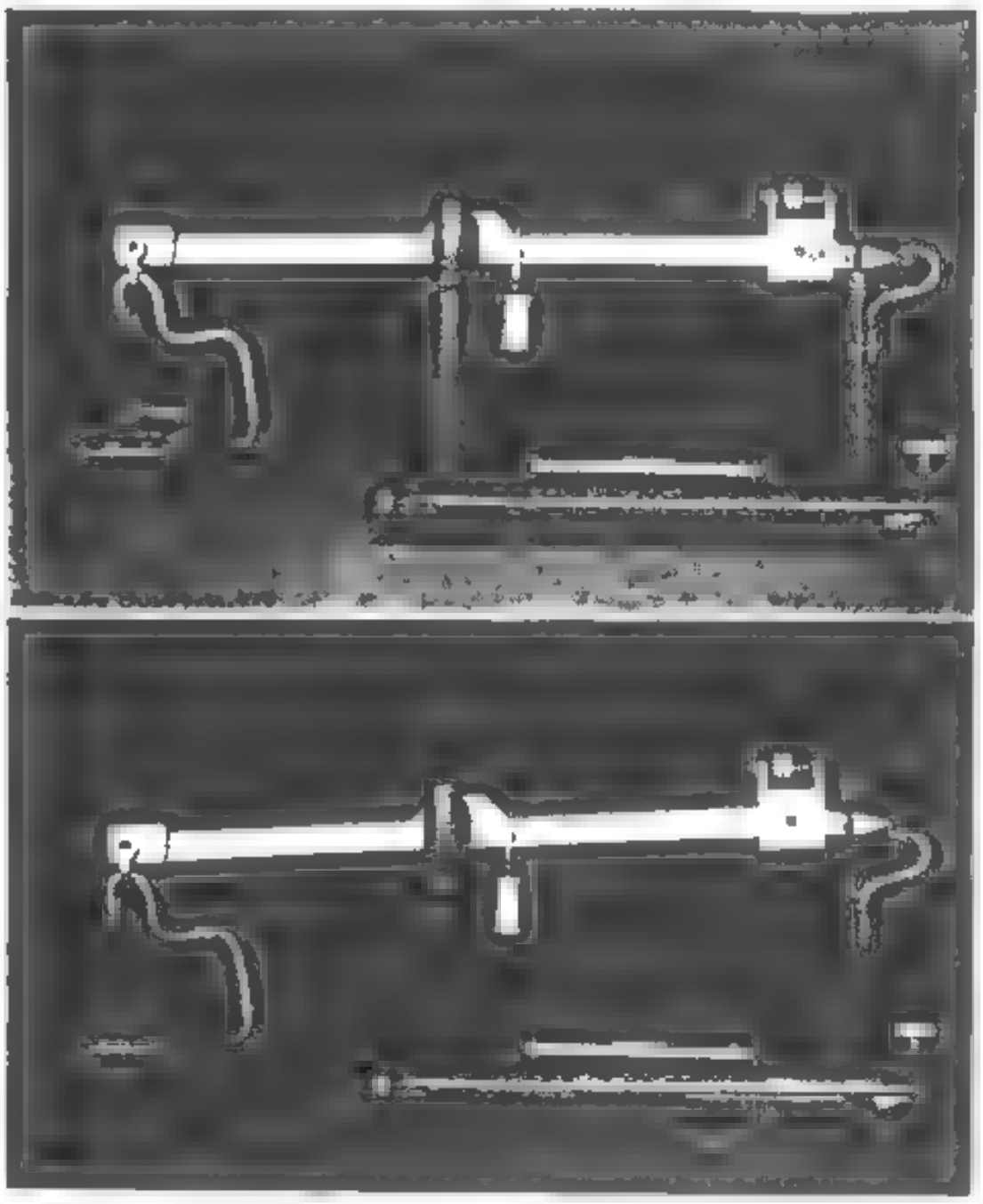
Loading Blocks.

A loading block is a great convenience when charging cases, when charging them with smokeless powder it is almost a necessity. These loading blocks are merely blocks or boards with a series of holes bored nearly through them, so that the charged cases may be set in them without danger of their being knocked over. A loading block can be easily made by boring a series of holes through a board, then tacking or gluing another thin board to one side to form bottoms for the holes. The holes should be large enough in diameter to receive the heads of the cases easily. Loading blocks can be purchased from Bond or Belding & Mull if desired.

Bullets should never be seated in cases without first inspecting the charges. If charged cases are put into a loading block, the block can be tipped toward a good light, without danger of spilling the powder, and the heights of the charges observed. Having all the cases together in this way, any irregularity in the heights of charges will be observed at once, by comparison.

In the manufacture of commercial ammunition, electrical
244 or mechanical gauges are employed to verify the heights of the powder charges before the bullets are seated and with some cartridges the powder charges are again checked after the ammunition is completed. This final verification of the charge is accomplished by weighing the complete cartridge. This weighing will not show up minor variations in charges, because of the variations in the weights of bullets and cartridge cases themselves, but it does serve to eliminate cartridges that are seriously overloaded.

Pistol and revolver cartridges can not be checked by weighing, because the permissible variations in the weights of bullets and cases sometimes exceed the total weight of the powder charge. If the manufacturers of ammunition must take such pains to insure the safe loading of their ammunition, the handloader certainly can not afford to be less careful. *Always* inspect your powder charges before seating bullets.



Illustrating poor sensitivity in a powder scale—a condition where the beam "sticks". Scale appears to be alright when charge is first weighed, but if scale pan is touched with the tip of a pencil it drops and will not return to original position. The only solution is to return such scales to the manufacturer for adjustment and correction

PLATE XVII

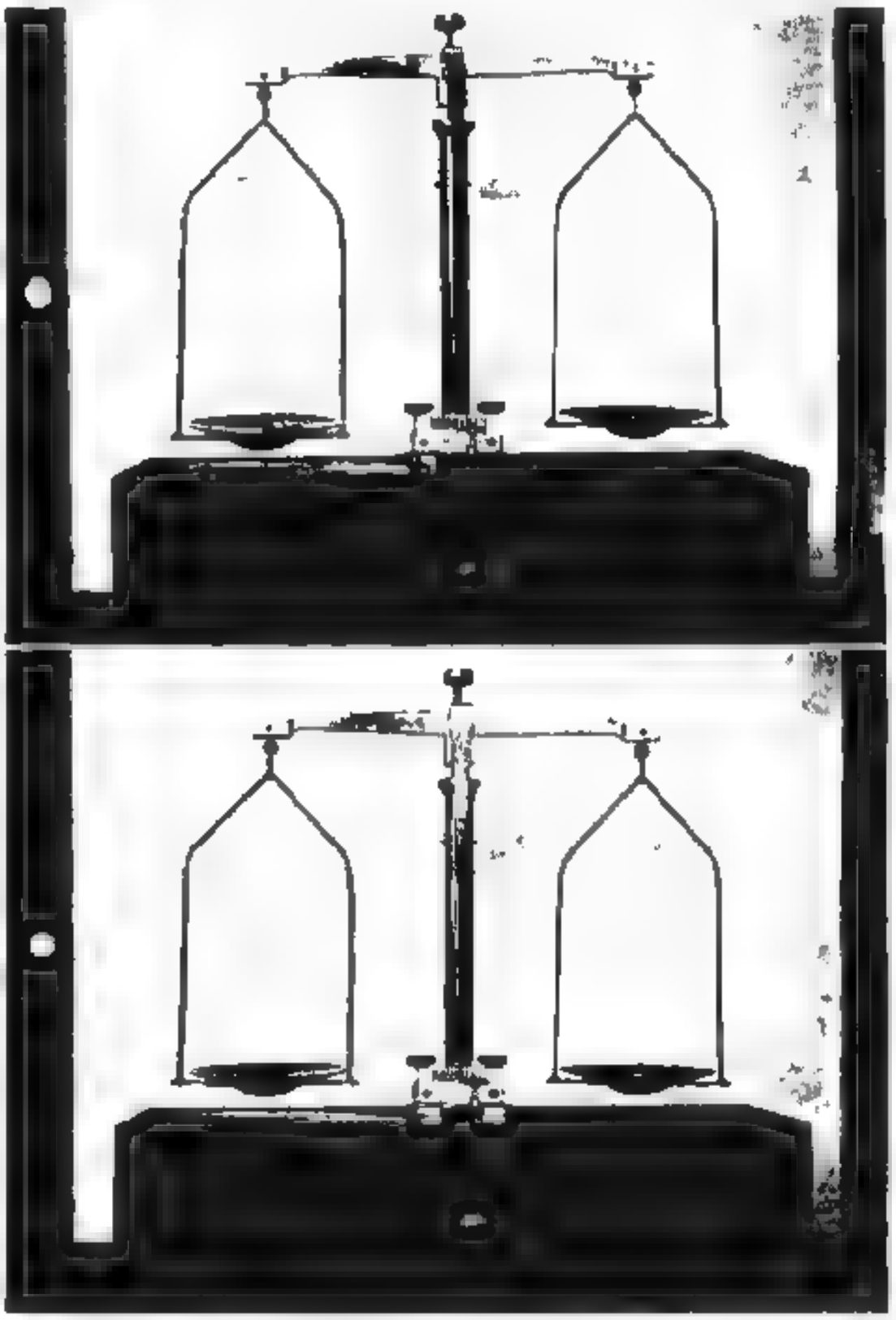
Chapter Ten

POWDER SCALES AND BALANCES.

A balance or scale that is reasonably sensitive is useful but not necessary for the loading of ammunition for all ordinary use. When the very finest long range accuracy is desired, or the ammunition is being loaded with over-charges of powder that develop pressures enroaching upon the margin of safety of the arm, a good scale becomes a necessity. There are a number of scales and balances selling at from seven to twenty dollars that are amply accurate for this purpose and, contrary to popular belief, they do not have to be sensitive to "a tenth of a grain." Even though a scale has this degree of sensitivity, it is improbable that the average handloader can load a series of cartridges with such a small tolerance, and the idea that charges have to be accurate to this degree is pure hokum. I do not mean that it is not desirable to have powder charges as uniform as possible, nor that it would not be desirable to keep them uniform within this magic limit of one tenth of a grain; I merely state that such accuracy can not be obtained with certainty, even *with* a scale sensitive to one tenth of a grain.

Now, in case there are some individuals disposed to rear up on their hind legs over such a heretical statement, let's look at the subject from an abstract standpoint, before going into the practical use of scales and balances. If you have a rifle and ammunition capable of shooting two inch groups at one hundred yards, you can't shoot possibles with it *all* the time, because it leaves nothing for the human error. 246
Two inch groups and a two inch bullseye is just like putting a two inch plug into a two inch hole. (And there is some question as to whether that can be done.) On the other hand, if the rifle will shoot *one* inch groups, we can shoot possibles with it frequently enough to feel gratified and *sometimes* we will get groups of one inch or even less. The same principle holds true with powder scales. The human element plays just as great a part in weighing powder as it does in shooting, and there must be some leeway in the accuracy or sensitivity of the scales to take care of it. Furthermore, a scale that may have been sensitive to a tenth of a grain when it left the factory may not be that when you get it and even if it is, it will not stay that way indefinitely. With the powder scales commonly used, it is possible to keep charges within *two* tenths of a grain all the time and within one tenth of a grain some of the time, provided the scale is in good condition, clean, and is used with care. Anyhow, two tenths of a grain is accurate enough.

Now let's look a bit closer at the practical side of this question. The accuracy of a scale or balance depends upon two things; its sensitivity and the accuracy of the weights used. The sensitivity is the ability of the scale to register small differences in weights with uniformity and precision. This depends upon a number of things, but by far the most important is the knife edge that supports the beam and the bearings upon which it rests. In the more expensive balances that are sensitive to from one hundredth to one thousandth of a grain, these knife edges are very sharp and 245 rest upon bearings of agate or other hard substances, into which the edge can not cut. Such balances are alright for laboratory use, but for the practical weighing of powder charges they are not worth a damn. They are so sensitive that it takes forever for them to come to rest. A person skilled in their use can weigh about two charges per minute and keep the charges within one tenth of a grain (?) but 247 to weigh anything to the limits of accuracy of the balance would tax the patience of Job. Such balances are often mounted on cement bases that pass through and are entirely independent of the building in which they are located so as to be free from any vibration or jar. The normal breathing of a person will disturb them, and their accuracy is too great to be of practical value for weighing powder charges.



Illustrating proper condition of good sensitivity in a balance. Lower shows index pointer at zero despite efforts to throw it off. Upper view shows a one-tenth grain weight in one pan, which throws pointer off, yet it returns to same position every time. A scale or balance as accurate and responsive as this is suitable for use with maximum charges.

[illegible] XVIII

The scales and balances ordinarily used for weighing powder charges and costing up to twenty dollars, while crude in comparison, are much more practical and are amply accurate for the purpose. Their bearings are either of steel or iron, and the knife edges are not usually dead

sharp but have just enough of the edge taken off so that they will not cut into the bearings.

In addition to the main bearing, there are bearings where the weight or weights are suspended. These must be free, for if they bind the least bit the sensitivity of the scale will be interfered with. The ends of the knife edges should not bear upon the end caps of the bearings and every precaution should be taken to see that all pivot points are free and that they oscillate easily.

Oil should not be used on the bearings of powder scales. The use of a small quantity of high grade watch oil may be justified at times, where climatic conditions are conducive to the formation of rust, but after its application, the oil should be wiped off completely. Dust is apt to accumulate in the bearings where it will impede the free movement of the beam of the scale. The presence of any oil will cause dust to stick, in addition to the possibility of the oil gumming which, in itself, is bad enough. A camel's hair brush is convenient for dusting the bearings. Don't blow on them, as the condensed moisture from your breath may promote rusting.

Leveling the Scale. The surface upon which a scale is placed and used should be as level as possible. Some scales and balances have levels mounted on them, by means of which they may be precisely leveled but in a class B 248
or class C balance, such as are used for weighing powders, the absence of a level is not important. The instrument can be brought to balance by raising one end of the base slightly with strips of paper or cardboard, or a small metal level can be used if the upper surface of the base is smooth and flat. The important thing is to have the beam or pointer of the scale oscillate freely and come to rest at the zero point. If this is accomplished without leveling the base, it is important that the base be not moved while the scale is in use. Movement of the base may change its angle and throw the scale out of balance and if it should become moved, inadvertently or for a reason, the zero balance should be checked before any more powder charges are weighed.

Checking for Sensitivity. Most scales have some kind of an adjustable counterweight or rider, by means of which the balance can be brought to zero when the base is level. Such devices are useful on any scale but they are of special advantage on scales having levels incorporated in their bases. When the base is leveled and the counterweight is adjusted to zero on the beam, the scale will be in permanent adjustment and, whenever it is used, it will only be necessary to level the base in order to bring the beam to a zero balance. When the scale is set up, it should be checked for sensitivity. To do this, adjust the scale approximately for balance and when it is at rest, push the beam down carefully and see whether or not it comes up to the point it started from. Now, it doesn't take a crowbar or the weight of a finger to push the beam down, so to make a check that is worth anything, a good deal of care must be used. The point of a camel's hair brush or the tip of a well sharpened lead pencil applied delicately to the beam, near the knife edge, will serve, provided one has a delicate "touch." I prefer the pencil. These tools, carefully used, are also a useful aid in bringing the beam to rest quickly when weighing powder charges. Try making the beam stay below center
249 several times and if the beam always returns to its original position, reverse the process and try to make the beam stay above center. If the beam shows no tendency to "stick," the scale is all right for sensitivity.

The two illustrations of a Fairbanks Assay scale shown give a graphic example of the result of such a check. It will be seen that in one picture the beam is stationary somewhat below the zero pointer, while in the other it is considerably above. In ordinary use, this scale will not show such a wide variation and it is proper to state that this scale is shown to demonstrate a particular condition and not as any indication that this model of scale is inaccurate. It may not be the best for the purpose of weighing powder charges, but it is plenty good enough.

By way of comparing the condition just referred to with one of good sensitivity, two pictures of a balance are shown. In one, the balance is at zero, after trying to throw it off one way or the other. No matter what was done, the index pointer would always settle down to zero. In the other picture the balance has a .1 grain weight in one pan. The tip of the pointer can be seen as a dark mark, three graduations to the right, but actually it is not quite that far and only appears so because of the angle from which the picture was taken. However, the important thing is that, no matter how the beam is moved, it will return to the same original position. Any scale or balance that will not register the same every time with a 1/10 grain weight can hardly be expected to weigh powder charges with that degree of uniformity, no matter how carefully it is used.

Sticking of Beam. Sometimes a scale will develop a pernicious habit of sticking. More and more powder is put onto the pan with no movement of the beam until, suddenly it bobs up to its highest position and a very appreciable quantity of powder has to be removed to bring the scale to balance. Then again, adding powder, a few grains at a time, may bring the scale gradually to the zero point of balance, but if a little pressure is applied to
250 the side of the beam from which the powder is suspended, it will be found that the charge is heavier than was supposed. All of which means that the real weight of the powder charge may be different from what the scale says it is. When a scale behaves in this way with the knife edge and bearings clean, the best bet is to return it to the manufacturer (not the dealer you bought it from) for adjustment. This assumes that the scale is one of a good enough grade to register tenths of a grain when in good condition. Where there is a tendency to stick, or a lack of sensitivity, no artificial means of bringing the scale beam to rest should be used. On the contrary, the beam should be set in motion several times to see whether or not it will come to rest at about the same point each time.

Use of Scale for Setting Powder Measure.

This is the most common use for a powder scale. To use it efficiently and set the measure quickly and accurately, the latter should first be set according to the table appropriate for it and operated a few times to settle the powder and establish the lines of flow. Then set the scale to weigh

five times the weight of the charge you desire. Measure out five charges and put the powder on the pan of the scale. Add or take off weights to determine the error, then adjust the measure for one fifth the error, repeating the process until the weight of five charges is correct.

Working with only one charge at a time is likely to be tedious work and result in many unnecessary changes in the setting of the measure. Some fine grained powders will measure so accurately and uniformly through a mechanical powder measure that there is nothing to be gained by weighing them, but the coarser grained powders will show some variation from charge to charge. These variations are not greater than those found in factory loaded ammunition, nor are they sufficient to cause dangerous pressures in normal charges. But as far as the powder measure is concerned, it can only be adjusted to throw an *average* charge that is correct. It is well to place the scales close to the measure and to check the latter from time to time, but in 251
doing this follow the procedure of weighing five charges or, for that matter, any number that will give an average result.

When measuring charges with a mechanical measure, the scale supplements the measure, but when weighing them the situation is reversed and the measure may be used to supplement the scale. For weighed charges, adjust the measure to throw a charge slightly under the desired weight. Throw the charge onto the pan of the scale and, by hand, add the few grains of powder necessary to bring the beam to balance.

Fairbanks Assay Scale. This scale has long been a stand-by for weighing powder charges and it is satisfactory for the purpose. I believe that its popularity is due to the fact that it was at one time about the only scale available for the purpose. It has a level in the base, with an adjustable screw support at one end of the base for leveling. The beam is provided with an adjustable counterweight for zeroing the balance of the beam when the base is level.

The beam itself is notched on both sides of the knife edge and carries two permanently attached weights, the small weight on one side weighing up to five grains, by tenths of a grain, and the large weight being adjustable in five grain increments. This feature has been much touted as an advantage and it is true that the weights can not become lost, but the advantage of a notched beam is questionable where exact weights are desired. In the first place, there is a limit to the accuracy with which these notches can be cut. Such variation as there is does not amount to anything on the tenth grain notches, but if the scale be checked with a set of accurate weights it will be found that the five grain notches are sometimes a tenth of a grain or more off. These errors are of no practical importance and they are not cumulative, that is, they do not increase as the weight is moved along the beam. They merely occur in some notches and not in others. Due to 252
tool marks in the notches and to the presence of unpolished plating, the hanging weights sometimes catch on a minute projection or rough spot and do not hang at the very bottom of the groove they are in. This is not a common occurrence, but it should be watched for when setting the scale. However, it is a good powder scale for general usage and its sensitivity is not great enough to prevent the beam from coming to rest quickly.

Pacific Scale. This scale is somewhat similar in appearance to the Frankbanks, but is entirely different in principle. It has no level nor means of leveling and it does not have to be adjusted for balance without weights on the pan. To use it, the scale is placed upon the table and weights to the extent of the weight of powder charge desired are put on the pan. The scale is then brought to balance by means of a threaded nut and lock nut on the beam, after which the weights are removed. When the amount of powder in the pan is correct to balance the beam, the weight of the charge will be the same as that of the weights used to adjust the scale. As long as the original position of the *base* is not changed, the scale will weigh charges accurately. If the base is moved, the balance of the scale should be checked as when first adjusting it.

This is a low priced scale, but a good one. The knife edges are one piece and are stiff and rigid, being formed on a flat steel plate that is locked against a square shoulder on the beam. There is little chance of their getting out of alignment. The bearings are round and of steel so that, theoretically, the knife edges rest on points. In theory, this is bad design but in this case it works O. K.

Some of these Pacific scales have a little paint on the bearings when they come from the factory and this should be removed if present. Care should also be taken to see that the knife edges are in the center of the bearings and that there is no interference between them and the grooves in which they are set.

253 ***Bond No. 80 Scale.*** This is in reality a Brown & Sharp yarn scale. It is a sensitive and accurate scale, well adapted for weighing powder charges. The base is provided with a level and means for leveling, and as this scale is correctly adjusted at the factory, no counter weight for balancing is necessary. Should the scale get slightly out of adjustment and fail to balance exactly with the base level, the adjusting screw may be used to bring the beam to balance without reference to the level in the base. The beam is graduated to twenty grains by tenths of a grain and is provided with a small sliding weight. A set of weights are provided for weighing quantities in excess of twenty grains and they are in such denominations as will permit any quantity to be weighed in increments of tenths of a grain, up to the limit of the scale. The writer has used this type of scale for many years in figuring costs of woven fabrics, as well as for weighing powder, and has found only one minor fault with it. The sliding weight on the beam is not fixed in its position and the jar incident to removing and replacing the pan will often cause it to move. It is necessary to keep an eye on it and see that it is kept in the correct position when weighing charges, but as this can be done almost without conscious effort, it can not be considered as a fault.

BALANCES.

Where the greatest accuracy is desired, I consider a good balance superior to a good scale. Balances are commonly graded as grades A, B, and C. Grade A balances

are expensive, their extreme sensitivity makes them slow to use, and they will not develop their full accuracy except in the hands of a person experienced in their use. They can be classed as unsatisfactory for the practical loading of ammunition. This may sound like a strange thing to say; it will probably only be taken at its face value by those who have breathed in short gasps or held their breath most of an afternoon while trying to weigh a dozen or so charges on one of them.

Class C balances have a sensibility reciprocal of from 254
¼ to ⅛ grain and they are satisfactory for weighing all but maximum charges.

This leaves the Class B balances, which are really the ones best adapted for weighing powder charges. They are amply sensitive, but as a rule slower to use than a scale. They can be obtained at a moderate price, varying from about fifteen to twenty dollars, and of a sensitivity of 1/10 grain. The No. 010 and 991 balances made by Henry Troemner of Philadelphia, one of the best known manufacturers of scales and balances in the country, are much used and can unhesitatingly be recommended for the weighing of powder charges.

Weighing Accessories and Gadgets. There are a number of ways in which a handloader can improvise little gadgets that will help to keep his scale or balance in good condition, or even to improve its usefulness. I do not mean by this that he can or should attempt any amateur blacksmithing on the scales themselves but there are a number of accessories which any handy man can make.

As the bearing of a scale is the very seat of its sensitivity, every precaution should be taken to keep this bearing or knife edge in perfect condition. If the scale is not to be used for some time, it is best to dismount the beam, thus taking the weight off from the knife edges. Balances are usually provided with a lever by means of which the bearing may be raised or lowered, but even in the lower position the weight is not always taken off the knife edge. Pieces of cardboard of suitable thickness can be placed under the hangers, so that with the bearing in its lowest position the beam will be relieved of the weight of the hangers and pans.

If the scale has a permanent place of abode and is not taken down and stowed away after each use, it is a good plan to protect it from dust. The better grades of balances are supplied with glass cases, the front of which can be slid up to open when the balance is being used, a counter-
weight or catch holding it open. This is a very nice and 255
convenient arrangement, but the less fortunate brethren can keep just about as much dust off their scales by inverting a cardboard box over them. Of course the cardboard box can be elaborated on, and a person handy with tools can make a very creditable case of ply wood, or even of glass, at very small expense. Such a case may not be absolutely dust proof but it will keep the greater part of the dust off.

The shallow pans with which most scales and balances are equipped are not very convenient for pouring powder out of, once a charge has been weighed. As a matter of fact, they are so shallow that in pouring any of the coarser grained powders onto them, some of the kernels are likely to bounce off. When using such pans, a funnel must be employed to pour the charge into a cartridge case. One can be rolled out from a sheet of heavy bond paper but a much better one can be made from a small seamless aluminum funnel and a drop tube from a powder measure. These aluminum funnels can be obtained from any department or five and ten cent store, and a powder measure drop tube from any of the loading tool manufacturers. The spout or outlet of the funnel can be forced into the upper tapered end of the drop tube, and there you are. The drop tube can be placed over the mouth of the case and the powder poured into the funnel from the scale pan without danger of spilling any.

Where balances are being used regularly for weighing powder charges, they are often equipped with a scuttle or bucket-like aluminum pan, with a spout which permits the powder to be poured directly from the pan into the cartridge case. This is a great convenience and the handloader can improvise something of the kind from light sheet metal. If he is real clever, he can make it to fit the hanger of the balance and thereby eliminate the weight of the regular pan, but otherwise it will have to be placed on the pan, in which event a tare or counterweight of equal weight will have to be made for the other pan, in order to offset the added weight of the bucket. The counter weights provided
256 for the normal balancing of the beam will be entirely inadequate for this purpose. The tare weight can be made from any piece of metal filed down so as to make it exactly the proper weight. Regular scale weights should not be used for this purpose, as they may become confused with those representing the weight of the powder charge.

The bucket should be kept as light in weight as possible, thin sheet brass or copper being used in making it. Aluminum is better still but it can not be readily soldered. An aluminum sugar scoop, which can be purchased in almost any store, contains an ample amount of metal for the making of such a bucket. Aluminum is soft and easily cut or bent, but the seams will have to be filled with liquid solder in the absence of special aluminum solder, for there must be no folds or seams in which fine grained powders may become caught. The metal left for the spout should be wide enough to fold completely over with the edges butted together, so as to form a tube small enough for its end to be entered in the cartridge case. This isn't as much of a job as it sounds; with a small hammer, a pair of scissors and a file, a very creditable piece of work can be turned out.

Incidentally, one of these small aluminum scoops, just as it comes from the store, is very handy for pouring powder back into the canister when one has finished with it. It is only necessary to squeeze the mouth of the scoop down narrow, then close its top edges over with the fingers. Powder from the measure or the box from which it was being dipped can be dumped into the scoop and then poured directly into the canister.

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Chapter Eleven

HANDLOADING VS. BALLISTICS.

It is customary in any work on the subject of handloading ammunition to describe and discuss the various

types and makes of loading tools which are on the market. This will not be done in this book for two reasons. In the first place, all one can do in a discussion of these tools is to express opinions and point out faults or virtues, or at least those things which the particular writer considers as faults and virtues. After all, these are but personal opinions and they oftentimes create an idea in the mind of the reader that one particular tool is infinitely superior to another, or possesses certain advantages in some of its features. These opinions, and the impressions created by them, oftentimes work to the disadvantage of some particular manufacturer, even though they are not intended to do so.

As a matter of fact, any of the loading tools now on the market, with one exception, will load safe and accurate ammunition if they are used intelligently and with careful thought as to what must be accomplished in the finished ammunition. This does not mean that the best results will be obtained by using the tools in accordance with the simple directions furnished by the manufacturers, even though these directions may be adequate for the loading of pretty good ammunition.

258 As new loading tools make their appearance on the market, they are usually written up and described by the gun editors of the various shooting publications and while, for the most part, an earnest attempt is made to describe such tools faithfully and to give an honest opinion regarding them, these opinions are of necessity based upon a limited use or examination of the machines referred to. This is only natural, but there is another aspect to such write-ups which is unfortunate, for one occasionally reads a glowing description of a loading tool or machine when it takes only a glance at the apparatus to see that it is of faulty design in many respects. When reading these effusive accounts one is forced to the conclusion that the tool written about was either given to the editor, who was thereby under obligation to the manufacturer to pay for it by saying some nice things, if possible; or, that the writer had an extremely limited knowledge of the subject.

The machine referred to above, as being one exception to those on the market which will load safe and satisfactory ammunition, is a case in point. This machine, when it first came out, was written of in most glowing terms. I am not going to give its name, nor describe it in any such detail which might serve to identify it. It is an excellent mechanical job and of ingenious design and I understand that there are a number of them in use that are giving results at least satisfactory to those who are using them. Suffice it to say that when this machine was placed before the writer, he took one look at it and refused to waste his time in any further playing with it. Shortly thereafter the gentleman who did try the machine out thoroughly, and who incidentally is experienced in the loading of ammunition, blew up a gun with the ammunition produced by it.

I am afraid some firms that are manufacturing loading tools have, for the most part, studied the loading of ammunition only superficially, if at all, and that they are more concerned with turning out tools and machines that will make things which look like cartridges than in considering

259 the effects produced on the cartridge by the various appliances and attachments of the loading device. If the newer loading tools have a fault, it is in this confounded effort to combine operations and thereby load ammunition more rapidly. In reloading ammunition, or in manufacturing it, speed of production is always a secondary consideration. Safety is of primary importance and it is dependent largely, if not entirely, upon proper inspection—on the subject of which a considerable amount of space has already been given throughout this book.

It is true that some ammunition manufacturing and loading machinery performs a series of operations without permitting hand gauging or visual inspection of the work. BUT—all such machines are equipped with mechanical or electrical devices which perform the proper inspection necessary to insure the safety and quality of the finished product. These inspection or gauging devices are not depended upon to perform their functions unfailingly. They are subjected to continuous tests and checks by the operator of the machine, who frequently inserts cartridges or components containing the defects that the detectors are supposed to pick out, to make sure that the apparatus is functioning perfectly. The moment one of these defective cartridges or components passes its detector, the machine is shut down and a machine setter is called to make the proper adjustments. Then, of course, there is always the foreman who is around to make sure that the operator uses the defective samples with sufficient frequency. This is vastly different from a loading tool that perfunctorily performs a series of operations without consideration of the quality of product which comes out of the other end of the machine.

It is not to be understood from these remarks that any tool which combines loading operations isn't any good for, even though the combination of operations is unwise, it is usually possible for the operator of the tool to separate the operations and perform them one at a time. A simple
260 example of this is the combining of the operation of expelling fired primers and the seating of new ones. This is not practical, is prejudicial to the best accuracy in ammunition, and with heavy loads may actually be unsafe. Yet it would be unwise to condemn any reloading tool, merely because it combines these two operations, provided the design of the tool will permit the operator to separate them. Principally for these reasons, the different makes of tools will not be referred to or compared, but rather the process of loading will be viewed and discussed in the light of the results which must be accomplished. In this way the text will serve for use with any type of loading tool—past, present or future. The loading of good ammunition is more of a ballistic problem than a mechanical one and it is the ballistic phase that manufacturers and designers of loading tools apparently ignore.

In order to tie in the performance and use of loading tools to this ballistic phase of handloading, the general subject of ballistics will first be briefly discussed, then the sequence of events that take place when a firearm is discharged. The rifle will be used as a basis for a description of the loading of ammunition, after which the peculiar

problems relating to the revolver and automatic arms will be given.

Some of this may be a duplication of what has already been written in other parts of the book, though from a different viewpoint, but it is necessary to consider this sequence of events chronologically, even though some of them may have been referred to in considering the performance of various ammunition components.

The science of ballistics is an interesting one to most shooters but it is not the purpose of this book to go into the theoretical or mathematical side of the subject, rather, to stick to the practical aspects. As a matter of fact, mathematical ballistic calculations are about as useful to the handloader as the proverbial silk pajamas are to an Eskimo, because the application of practically all ballistic formulae are dependent upon definite numerical values which can 261
only be obtained with the facilities of a ballistic laboratory.

Barrel Vibrations.
Stripped barrel and action in lower view shows wires strung evenly along the barrel. By tapping receiver tang with a mallet, the wires are moved about by the barrel vibrations and group themselves at the nodes—as shown in upper view.

Illustrating the manner in which the .45 Automatic cartridge is positioned and held in the chamber of the service pistol.

PLATE XIX.

For example, the muzzle velocity of any given cartridge, as printed on the cartridge box or in the ballistic tables of the manufacturer, cannot be used as the basis for any calculations because these figures cannot be depended upon to be correct. This is due largely to changes that are necessary in the loading of the ammunition when changing from one lot of powder to another. The same thing holds true of pressures and such pressure figures as are published in tables of charges based upon the results obtained with one load of cartridges in one gun.

As a concrete example of the variations in the performance of different loads of ammunition we can consider the cal. .30-06 M1 cartridge, which is the present standard rifle and machine gun cartridge in the United States army. The standard average instrumental velocity of this cartridge is prescribed in specifications as 2640 f.s., plus or minus a small tolerance. For tactical reasons this velocity must be maintained from one lot of ammunition to another to a much higher degree of uniformity than is necessary in any commercial sporting cartridge. Yet every experienced rifleman knows that different lots of this ammunition may require a considerable difference in sight settings, especially at the longer ranges. Therefore, the handloader should judge his ammunition from the view point of actual performance, rather than by fooling around with any mechanical computations.

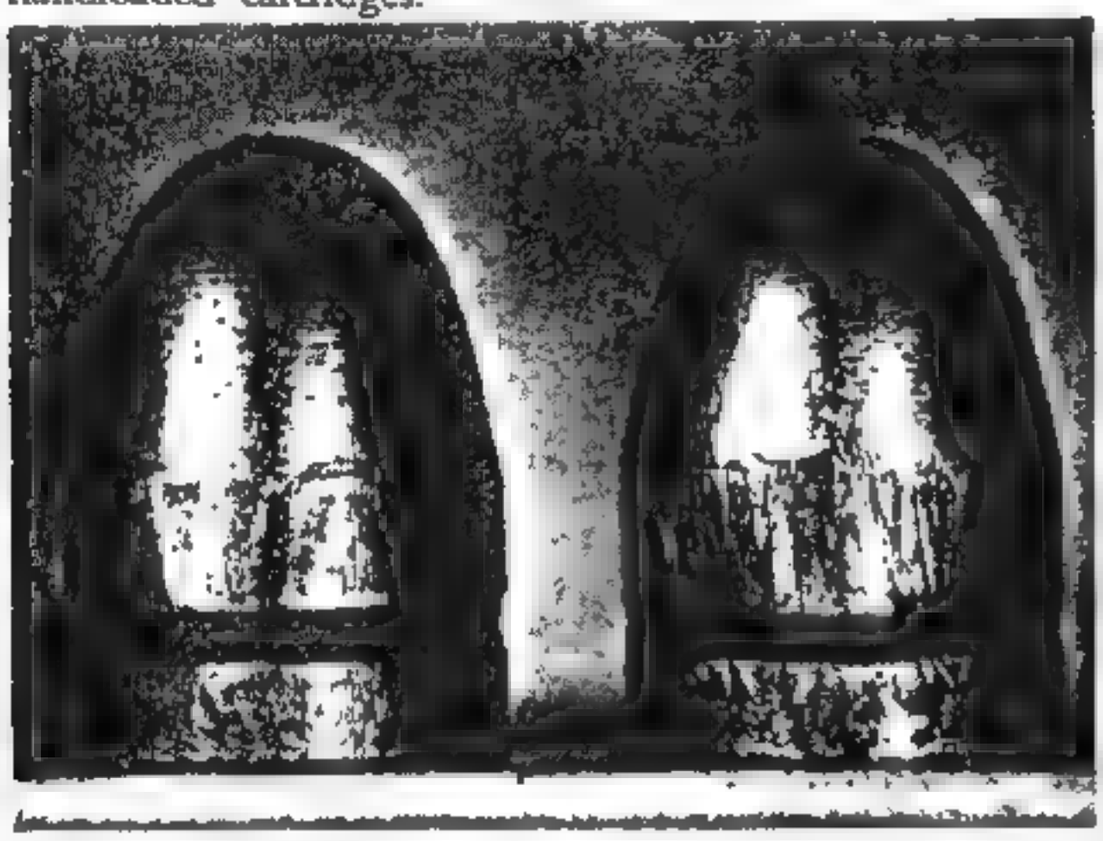
Another example which will show that mechanical computations give only an approximate result, can be found in the firing of seacoast cannon. The range finding and load data for every shot fired out of one of these big guns is a matter of permanent record. Furthermore, there is provision for fastening two pressure gauges in the mushroom heads of the breech blocks of these guns so that the actual chamber pressures developed can be measured, and the powder charges adjusted properly before commencing any
262 range firing. In spite of these complete records and the duplication of charges that have been fired in the gun before, it is not uncommon for the first shots fired at a target to be as much as a thousand yards or more over or short of the target, necessitating an arbitrary correction in order to place the shots in the vicinity of the target—and this without any error on the part of the range or loading details. Therefore, we are going to be very practical in treating the subject of ballistics and leave the theoretical aspects to the text books, where they properly belong.

The subject of ballistics is divided into two parts: interior ballistics, which concerns the time between which the trigger of a firearm is pulled and the bullet is far enough out of the muzzle of the gun so that it is no longer affected by the expanding gasses; and exterior ballistics, which has to do with the free movement of the bullet or projectile through the atmosphere.

Interior Ballistics.

Interior ballistics, as related to small arms, is divided into four distinct phases. The first is the interval between the time the sear is released and the firing pin impresses itself into the primer sufficiently to promote ignition of the latter. The second phase represents the time required for the primer to transmit its flash to the powder charge and ignite a sufficient amount of it to promote combustion of the remainder. The third is the interval between the time the powder begins to burn, and transform into gasses, and the time that the bullet starts to move forward. The fourth and last phase is the time between the initial movement of the bullet and the time that the bullet is out of the muzzle and beyond the effect of the expanding powder gasses

behind it. With proper facilities, these several time elements can be calculated or estimated, it being necessary to measure such intervals in units of one ten-thousandth of a second—a time measurement that is too small for human conception. However, the time of each of these phases will differ considerably in different cartridges, and will change with any change in the components of the loading 263
of any cartridge. Therefore, there is no use in even attempting to suggest what these time intervals might be in handloaded cartridges.



Bullets which skidded.
A couple of bullets that never did get rotated properly by the rifling. Too soft and too short for the powder charges used.

Gas Cutting
The bullet on the left was fired through a barrel with deep grooves. The one on the right through an oversize barrel. Note how the gas, rushing past both, has carried the edges of the bands away or rounded them.

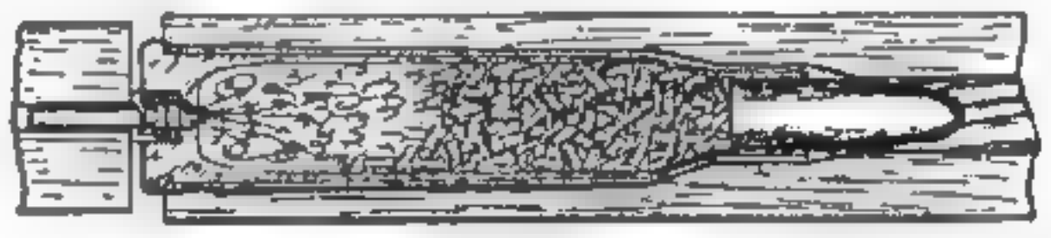
PLATE XX

The entire sequence of events, as mentioned above, is ordinarily referred to as the barrel time, although the true barrel time is more correctly that between the instant at which fire is produced in the primer and the bullet has left the muzzle of the gun. The time between the releasing of the sear and the production of fire in the primer is the lock time and has nothing to do with our handloading problem.

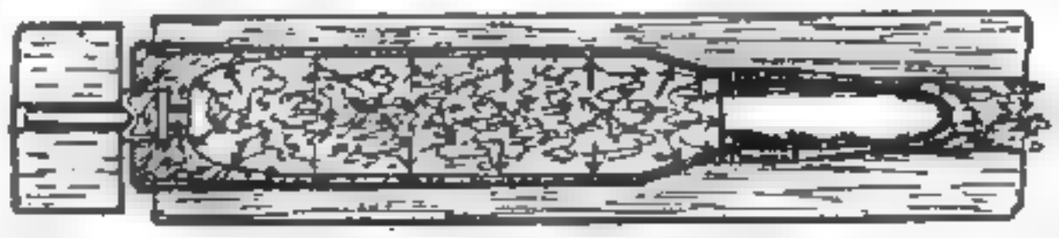
When a primer is struck by a firing pin with sufficient force to indent it appreciably, the priming pellet is pinched against the anvil and a flame is produced which passes through the vent or flash hole (sometimes more than one) in the bottom of the primer pocket and into the body of the cartridge case, where the propelling charge is located. This flame normally ignites more or less of the charge, which begins to burn at atmospheric pressure just as powder burns in the open air when ignited with a match. As the first grains of powder begin to burn, gas is given off which can find no escape from the closed chamber and as the volume of gas continues to increase, the pressure rises. This first evolution of gas is known as "new" or "young" gas and as it develops, and the pressure rises, the walls of the cartridge case are expanded and pressed against the walls of the chamber—the neck of the case sharing in this expansion. The bullet has not yet begun to move and, with the neck of the case expanded, the new gas rushes past the bullet, escaping out of the barrel ahead of it.

264

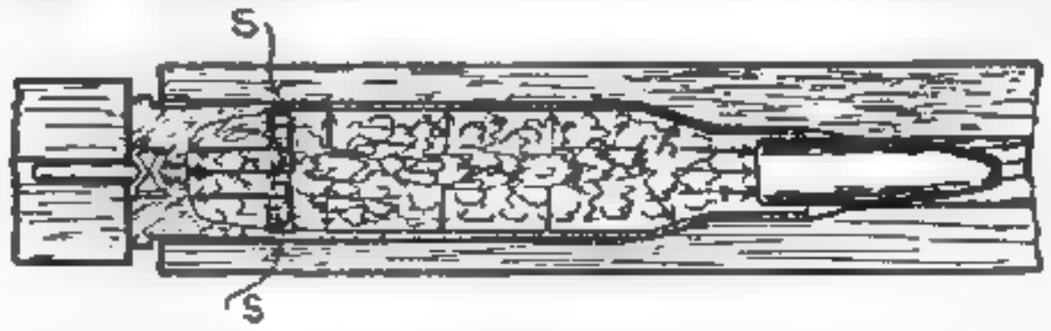
Firing pin has just struck primer, driving cartridge case forward and seating the rim of cartridge against back of barrel. Note clearance between cartridge and chamber, (exaggerated for purpose of illustrating what happens,) also headspace between head of cartridge and face of bolt.



Primer explodes, igniting the powder. Extremely violent action of the primer compound drives the primer partly out of case and back against breech block. Also drives powder grains forward against base of bullet.



Powder burns almost instantaneously, developing pressure of from 30,000 to 50,000 pounds per square inch,. This pressure expands the thin forward part of cartridge case against the walls of chamber, but cannot expand the thick part near cartridge head. Hence front part of cartridge grips walls of chamber tightly, while extreme rear part does not. Neck of cartridge case expands and gas escapes around bullet before it starts to move.



Bullet moves forward, sealing the bore as it does so. Back end of cartridge moves to the rear until it comes against breech block, while front part of cartridge remains locked in place by pressure of gas holding it against chamber walls. Cartridge stretches at S and may rupture if headspace is excessive.

DETAILED ACTION OF RIFLE CARTRIDGE IN FIRING

It is a well known physical fact that motion cannot be produced except at the expense of time and, therefore, the bullet does not move immediately, as its inertia must first be overcome. Now, possibly the reader has seen either in the moving pictures, or in magazines, extremely slow motion pictures of a golfer driving a golf ball. The ball does not move off the tee immediately when the face of the
265 club comes in contact with it but proceeds to flatten out under the impact in a dough-like manner, shortly moving forward—still in contact with the club—gradually resuming its original spherical form and leaving the club due to its elasticity and the force of the blow imparted to it.

A somewhat similar condition occurs with a flat base bullet. With the passage of time, and the continually increasing gas pressure behind it, the bullet begins to move. But it does not all move at the same time, the base being the first part affected and moving independently of the point. This is not difficult to comprehend if you think of a bullet being fired against a hard surface, in which case the point of the bullet stops first while the base continues to move, causing more or less flattening of the point end or even complete disintegration of the bullet. A reverse condition takes place upon the initial movement of the bullet forward into the barrel. The base is moved first, and expands, and this degree of expansion is very considerable, even with flat base bullets having stiff jackets. The actual degree of expansion is limited only by the space available within the limits of the barrel and chamber. But finally the point of the bullet also begins to move and the bullet goes forward into the throat of the rifling, whereupon the escape of gas past the bullet is to all intents and purposes checked. The effort of the base to move faster than the point of the bullet may continue while the bullet is traveling as much as two or three inchs or more along the barrel, by which time the entire mass will have obtained the same velocity. This expansion of bullet bases is easily proven by sawing off the barrel just ahead of the chamber, firing a cartridge in it and recovering the bullet. The degree of expansion will naturally depend upon the hardness of the bullet and the force that is applied to it.

Barrel Vibrations. The disturbance caused by the
266 blow of the firing pin, the sudden expansion of gasses in the chamber, plus the shock of the bullet moving up against the throat in the barrel, sets up violent vibrations throughout the length of the barrel. These vibrations are divided into two distinct parts, one of which is a whip-like motion of the barrel and the other a true vibration such as occurs, for example, in the string of an instrument when it is picked. These vibrations have a very material effect upon the performance of the arm. If they are uniform from one shot to another, the rifle will shoot accurately, but if anything is done to disturb their uniformity, which incidentally can be effected by improper stocking, they may not be uniform from one shot to another and there will be a considerable dispersion, no matter how accurate the ammunition itself may be, nor how accurately the barrel may be bored, rifled and chambered.

The vibration of a barrel causes a very considerable angular movement of the muzzle and while this movement might be in any direction across a circle whose center is the center of the barrel, a barrel will almost always vibrate more or less in a vertical plane. This is natural and logical, because there is a certain amount of "droop" in a rifle barrel due to its length and weight. In a long, heavy cannon, the "droop" may amount to as much as a couple of inches, although it is, of course, only a very small amount in a rifle barrel. Nevertheless, when an arm is fired, the first tendency of the vibration is to overcome the "droop" so the barrel moves abruptly in an upward direction, a movement which is ordinarily referred to as "jump." The angle of departure of the bullet is the angle at which the barrel is elevated, plus the jump, plus or minus any angular movement of the muzzle itself due to vibration, at the instant that the bullet leaves.

Recoil. At the same time the barrel vibrations start, recoil commences, the recoil being the "equal and opposite reaction" to the movement of the bullet. The heavier the bullet or the higher its velocity, the greater the recoil is. In addition to the recoil induced by the movement of the bullet, which is known as the primary recoil, there is a
267 secondary recoil which is caused by the column of gas issuing from the muzzle and coming in contact with the resistance of the atmosphere. As this secondary recoil does not take place until after the bullet has left the muzzle, it has no effect on the angle of departure. The primary recoil does.

A rifle or pistol is normally supported below the line of recoil, the latter being coincident with the axis of the bore, and the effect of the recoil (other than that of unpleasantness to the shooter) is to cause the arm to rotate or attempt to rotate around the point of support. This causes the barrel to climb and move upward while the bullet is traveling through it and while the barrel is in a state of vibration. The movement of the barrel in recoil should not be confused with its movement due to vibration, when considering problems affecting them, but when shooting it is their combined action that governs the true angle of departure of the bullet.

The greater the recoil, the more the barrel will climb before the bullet gets out, provided that the barrel time is not reduced at the same time. If the velocity of the bullet is increased above normal while it is passing through the bore, it will leave the muzzle before the barrel has had time to climb as far as it might with a lighter load developing less recoil. But this is getting off the track and the point I wish to make here is that the barrel vibrates regardless of the amount of climb or jump from recoil and plays an important part in the accuracy that is developed on the target by the ammunition.

The general idea of barrel vibration can be seen clearly by means of a simple experiment which anyone can make. While it is not recommended that anyone remove the barrel and action of a rifle from its stock in order to try this experiment, nevertheless, the effect and violence of barrel vibrations can be seen by clamping the receiver of a rifle with only the barrel attached to it in a heavy vise bolted to a firm bench. If a "U" shape wire is hung over
268 the muzzle of the barrel and the tang of the receiver is

struck a moderate blow with a stick or raw-hide mallet, the wire will jump upward for an appreciable distance and may jump off the muzzle of the gun, and this with the receiver clamped tightly in a vise. If a number of these "U" shaped wires are hung at regular intervals along the barrel and the tang is tapped repeatedly with light blows, the wires will move along the barrel and group themselves at the nodes on it. As most barrels are tapered and the nodes are closer together in the heavier parts of the barrel than in the lighter, thinner parts, the separation of the spacers will not be uniform. The illustrations given on Plate XIX show the effects of barrel vibration, one picture showing the spacers arranged along the barrel and the other showing the same barrel after the tang of its receiver had been tapped a number of times without touching the spacers in any way.

The vibrations in the barrel of any well stocked rifle will be quite uniform from one shot to another as long as the ammunition is uniform, but if the ammunition is not uniform for any reason, whether it be from appreciable errors in the powder charge, variations in the weights of bullets, faulty ignition (whether from poor primers, primers which are not properly seated, or dirty primer pockets), mixed lots of cartridge cases of varying capacity, or a number of other causes, the angle of departure of the bullets will not be exactly the same from one shot to another.

The writer was once told that the subject of barrel vibration had nothing to do with handloaded ammunition. Perhaps it hasn't, but the handloading of ammunition has a lot to do with barrel vibration and if the barrel vibration is not reasonably uniform, the results obtained with the ammunition will be unsatisfactory.

Heavy barrels do not vibrate as much as light barrels and the vibrations will be more uniform from one shot to another because of the lesser disturbance of the barrel; the heavy barrel is not as susceptible to small differences that exist from one cartridge to another in the ammunition. 269
It is for this reason that heavy barrels shoot more consistently than light ones, rather than due to any special perfection in the rifling or chambering. A take-down rifle will not shoot as consistently as one with a solid frame, because of the looseness of the attachment between the barrel and the receiver, due to the take-down feature. Even though one of these arms may shoot quite well when new, it may change its center of impact considerably if taken down and put together again, and if frequently taken down the wear on the interrupted threads on the barrel and in the receiver ring will cause it to become less and less consistent in its shooting or we may say, less and less

If the bare barrel of a rifle is resting on any solid object, against the side of a tree, for example, when it is fired the arm will be thrown away from the point of support by the vibrations. Therefore, if a rest is used in testing ammunition, the rest should touch the forearm of the rifle and if it is a narrow rest the rifle should always be rested at exactly the same point. There are some prone and bench rests, and very good ones, in which the barrel of the rifle is secured in a clamp; excellent shooting can be done with some of these. While the clamp on the barrel may effect the normal vibration of the barrel, the clamp is affixed at one point and the vibration, although abnormal is consistently uniform.

Powder Gas Disturbances. But to get back to the movement of the bullet. After all parts of the bullet have attained an equal velocity, its movement along the bore of the vibrating barrel depends upon the kind and quantity of powder that is burned behind it. With normal charges of rifle powders, there is some acceleration of the bullet throughout the length of the barrel. This may be seen by cutting off segments of a rifle barrel and noting the drop in velocity of the bullet after each segment is cut off. But if a rifle is fired with a light charge of pistol powder, the powder will be consumed quickly and the bullet given
270 more or less of a bump or shove; as the bullet moves forward and the space behind it increases, the relatively small volume of gas available is unable to continue its accelerating effect on the bullet, the pressure drops rapidly, and the bullet may be retarded or slowed up by friction with the barrel before it leaves the muzzle. High pressures do not mean high muzzle velocities, as with a quick burning powder a gun can be burst before the bullet is out of the barrel, the gas pressure drops to nothing and the velocity of the bullet will be only that imparted to it before the burst occurred, less the retarding effect due to friction before it gets out of the muzzle of the gun.

As the bullet emerges from the muzzle of a barrel there is a tremendous gas disturbance behind it and the gasses, traveling at higher velocity than the bullet, envelop it. If the bases of all the bullets fired are perfectly flat, uniform and free from defects, the action of this expanding gas against the base of the bullet, when the latter is out of the gun, will be uniform from one shot to another. But if the bullet bases are appreciably defective, especially at the edges, the flight of such defective bullets will be affected by the gas.

For example, if a bullet has a nick or a serious casting defect in one side of its base, gas will escape through this as the bullet emerges from the muzzle of the gun, causing more or less tipping or "yaw" of the bullet. While such a bullet may by chance shoot into the same group with the rest, there is a much greater chance that it will not. In pistols and revolvers, where the pressures are low and the range at which such ammunition is fired is short, bullets with minor defects in their bases may appear to shoot fairly well for ordinary use, but not so with rifle bullets. The relatively high gas pressure behind rifle bullets, plus the longer ranges at which such bullets are usually fired, will cause a considerable dispersion if bullets with defective bases are used.

Boat-tail bullets do not behave the same as flat base
271 bullets. A flat base bullet expands under the influence of the powder gasses, but the tendency of a boat-tail bullet is to collapse under the same circumstances. The tapered base of these bullets causes the gasses to act as a wedge and try to force their way in between the bullet and the barrel. For this reason, boat-tail bullets are made with very hard cores and the true base of a boat-tail bullet may be considered as the line of junction between the boat-tail

taper and the cylindrical portion of the bullet. Special care must be taken in making such bullets that the boat-tail be concentric with the point of the bullet and that this junction point be in a plane at right angles to the axis of the bullet.

The term "interior ballistics" applies to a sequence of events which terminate when the projectile has left the muzzle of the gun and the report has had time to reach the ear of and register itself on the sensibilities of the firer. The time required for the report to reach the ear is very short and is normally about equal to that required for the bullet to get beyond the effect of the expanding gasses.

Exterior Ballistics.

A bullet suddenly projected in the atmosphere at a high velocity and with a severe gas disturbance behind it is subjected to rough treatment. In the early stages of its flight it may, and usually does, wobble considerably, at the same time deviating more or less from a plane through the axis of the bore. This instability of the bullet is sometimes referred to as "initial yaw." It is not the same in all bullets, as the shape of the bullet as well as the velocity at which it is travelling has a considerable effect on it. Any eccentric flight of the bullet may be further aggravated by a failure of the center of mass, or center of gravity, to coincide with the center of form.

When the bullet is passing through the rifling, which imparts rotation to it, it is forced to rotate around its center of form, being supported on all sides by the barrel, but when it emerges into the atmosphere, it will revolve around its center of mass. The effort to get these two 272
centers to coincide is one of the major problems of bullet manufacture. If a bullet jacket is thicker on one side than the other, or if the core is not of even density, the bullet will be eccentric in its flight throughout the legth of its trajectory. Likewise, a cast bullet can easily be slightly heavier on one side than on the other if the alloy from which it is cast is not kept properly fluxed and stirred. As has been previously mentioned under the subject of bullets, cast bullets frequently come from the mould slightly out of round; these little irregularities are usually trued up by sizing the bullets, but even if they are not and such bullets are fired as cast, they will be sized up and trued to a greater or less extent when they are forced through the bore of the rifle. On the other hand, a cast bullet or even a flat base jacketed bullet is up against a tough proposition when fired in a rifle having a loose chamber, particularly one that is loose at the neck, for as has already been pointed out, there is a brief instant during which the neck of the cartridge is expanded, letting go of the bullet, but in which the bullet has not begun to move forward, after which the base of the bullet begins to move and finally the point, until the bullet slaps up into the throat of the rifle. During this brief instant when the bullet is beginning its forward movement, it is a matter of chance as to how it moves up into the throat of the barrel and its angular entrance, coupled with the expansion which takes place, can cause the most perfect bullet to become slightly eccentric.

The disturbance of the bullet during its initial movement along its trajectory that is caused by its high velocity and the effect of the gas on it is temporary, but any eccentricity of rotation caused by failure of the center of gravity and the center of form to coincide will be permanent throughout the flight of the bullet.

Bullets driven at high velocity will usually make slightly oval holes in cardboard or paper screens placed at short distances from the muzzle of the gun which shows up 273
graphically the effect of initial yaw, but this wobbling of the bullet is also influenced by the thape and sectional density of the bullet and the rate at which the bullet is rotating.

Speed of Rotation. The speed of rotation depends upon the pitch of the rifling and the muzzle velocity of the bullet. For example; if the rifling in a barrel has a pitch of one turn in ten inches and a bullet it fired from it with a muzzle velocity of 2,000 feet per second or 24,000 inches per second, the bullet will, in one second, make as many complete rotations as 10 inches will go into 24,000 inches, or 2,400 rotations per second. However, if the same bullet is fired from the same gun at a velocity of 3,000 f.s. its rate of rotation will be increased to 3,600 revolutions per second. Long bullets must be rotated faster than short bullets to keep them stable in flight or to give them what is known as gyroscopic stability, and a long bullet of small caliber will never become stable in flight if it is driven at too low a velocity.

Trajectory. A projectile emerging from the muzzle of the gun has a tough job ahead of it, forcing its way through the atmosphere. Living in it as we do, we are apt to think that the atmosphere is just about nothing at all, but in reality it is a dense, movable combination of gasses which have a serious retarding effect upon the flight of a bullet or any other object passing through it. The elastic quality of the atmosphere is responsible for a considerable part of the recoil of a firearm, the action of the gas emerging at high pressure from the muzzle of the gun compresses the atmosphere while the reaction is to force the gun to the rear and the effect on the bullet is to continually slow it up in its flight. As the bullet is unsupported and is acted upon by the force of gravity which is constant, its rate of fall towards the earth is approximately equal to the normal acceleration of gravity while its forward movement is continually decreased by the atmosphere. The trajectory is therefore, always a modified parabola.

274 ***Drift.*** This rotational friction causes the bullet to "drift" slightly in the direction of its rotation or in the direction of the pitch of rifling. Because of the greater frictional area, a large caliber bullet will have a greater

The rotation of the bullet is not retarded to the same extent as its forward movement. The point of the bullet thrusts the atmosphere aside much as the prow of a boat thrusts water aside when passing through it, reducing the frictional effect of the atmosphere on the body of the bullet which after all does not involve any compression of the atmospheric medium. Bullets that have been fired at extreme ranges have been found to be rotating after they had lost their forward motion and the same is true of bullets that have been fired vertically, but the atmosphere does cause some retarding effect on the rotation.

amount of drift than a small caliber, all other things being equal. A bullet driven at high velocity from a rifle having a right hand twist may and frequently does move to the left of a vertical plane through the axis of the bore, immediately after leaving the muzzle, but this is due to yaw and not to atmospheric friction. Once the yaw is overcome, the bullet will commence its drift in the direction of rotation.

The trajectory of a bullet with relation to the bullet's performance can be divided into three parts: the part where initial yaw occurs, the part where the bullet flies truly and the part where yaw sets in again. The part in which the initial yaw is pronounced, which varies with the design of the bullet and the velocity at which it is driven, but which in high velocity rifles usually extends several hundred yards from the muzzle of the gun. As the remaining velocity of the bullet decreases, without appreciable decrease in the rotation, the bullet settles down to a steady flight and is said to "go to sleep" and this even flight continues until the loss in velocity and atmospheric friction is so great that the bullet begins to lose its gyroscopic stability. When this point is reached the bullet begins to wobble, 275
which increases its resistance to the atmosphere and it loses velocity rapidly. As its rate of forward travel decreases, the effect of the action of gravity becomes more pronounced and the bullet drops more rapidly towards the earth; if the angle of fire be high enough, the bullet will finally lose all forward velocity and drop straight down.

The calculation of trajectories and in fact, almost all exterior ballistic problems are dependant upon an accurate knowledge of the muzzle velocity of the bullet and a factor termed the "ballistic coefficient," which involves the sectional density of the bullet; that is, the bullet weight divided by the square of its diameter in inches plus a form factor having to do with the shape of the bullet. This applies to flat base bullets. It is a difficult matter to accurately determine the ballistic coefficient of any bullet over its entire trajectory and this coefficient, when determined, can only be applied while the bullet is stable in flight, because the minute a bullet commences to wobble, or is unstable, or eccentric in flight, the air resistance is increased and the normal ballistic coefficient becomes useless.

The most important part of the trajectory and what might be termed the must useful part is that in which the bullet is asleep and flying truly.

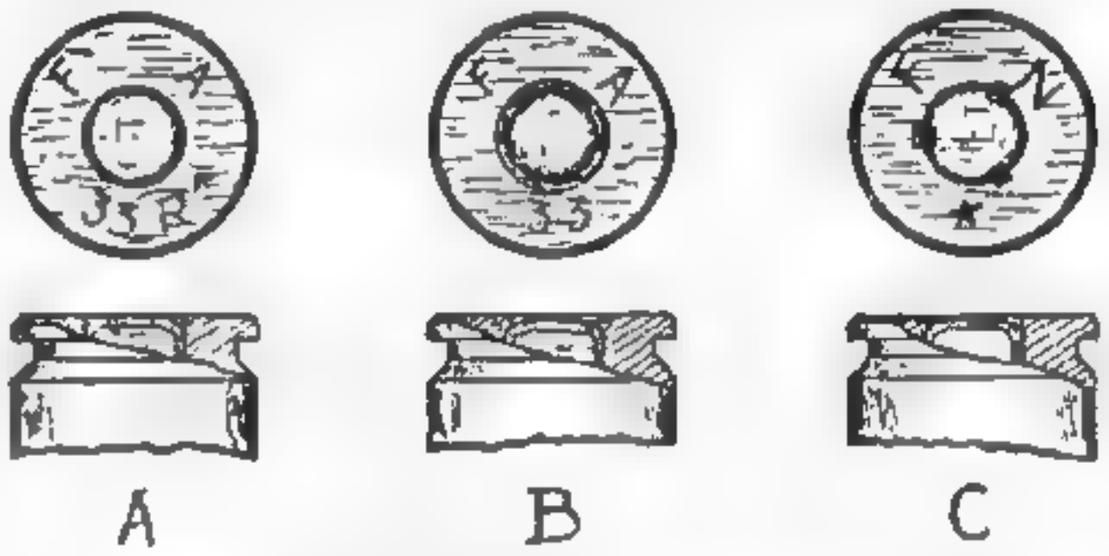
Chapter Twelve 276

HANDLOADING OPERATIONS.

Except for the quantity of powder used in loading ammunition, which affects the muzzle velocity, the entire problem of handloading is one intimately related to internal ballistics. The first operation presenting itself is that of decapping, provided one is about to reload fired cases. The expelling of fired primers is of little importance as far as methods are concerned and any old way of getting the primer out is perfectly satisfactory, provided the flash hole or vent in the cartridge case is not enlarged by the decapping pin or punch that is used. In extracting Berdan primers, care must be taken not to damage the anvil which is a part of the cartridge case, but we can practically skip that because Berdan primers are not used in American ammunition nor are cartridge cases of the Berdan type reloaded to any great extent.

DeCapping.

All reloading tools provide a means for expelling or pushing out fired primers in the form of a rod or punch that will pass freely through the mouth of the cartridge case. The end of the punch carries a small pin which in turn passes through the flash hole or vent in the case to force the fired primer out. These decapping punches are actuated by some mechanical means and sometimes operate under a very powerful leverage. This isn't a bad idea, because in military cartridges these primers are almost 277
always crimped in by having the brass in the head of the cartridge case compressed and upset around in the immediate vicinity of the primer pocket, making the mouth of the pocket smaller than the base. This makes primers especially difficult to push out. Sporting ammunition in other



Variations in Primer Crimping.
A—No crimp, as on National Match ammunition. B—Ring crimp, as on Cal. .30 Ml. C—3 point crimp, as on .50 Cal. ammunition and many foreign cartridges.

than military calibers is sometimes encountered with the primer crimped in also, so a little extra power or leverage in the reloading tool is not out of place at all on this operation.

The need for removing the crimp from the primer pockets of cartridge cases only exists where the primers have been crimped in and the crimp must be removed before new primers can be seated. We have already gone through the mechanics of reloading and what is written here is intended to apply to the operation of reloading tools with particular reference to the effect that their improper operation can have on the ballistics of the ammunition. Therefore, those little details that have no direct reference to the operation of reloading tools or machines will not be repeated in any detail.

RePriming. 278

When it comes to seating new primers, we are up against a real job. The manufacturer of ammunition does this with machines that automatically feed the cartridge cases and the primers in, and position the two in such a way that the seating punch will force the primer squarely into the primer pocket to the proper depth; the travel of the primer punch being adjusted to push the primer in

just so far and no more. Naturally this is far enough to press the edges of the primer anvil against the bottom of the primer pocket, but not enough to cause any disturbance or breakage of the primer pellet. This can be done in the factory very nicely because of the rather expensive and ingenious machines used for the purpose, and the fact that all the cartridge cases have primer pockets of a uniform depth and all the primers are uniform within certain small manufacturing tolerances.

The reloader is not in such a favorable position. As often as not he is using cartridge cases from different lots and which are frequently of different makes, with primer pockets that are not all the same depth. As likely as not he is using primers of a different make than the cartridge cases and I am sorry to say frequently pushing them down on top of a lot of dirt and corruption at the bottom of the primer pocket that decreases the depth of the latter. In addition, the reloader is using a loading tool that cannot possibly seat a primer properly if the operator does not use care and judgment in performing the operation.

Priming Punches. It is certainly desirable, but not absolutely necessary, that the shape of the business end of a priming punch conform very closely to the shape of the primer being seated. This is especially true of the new non-corrosive primers, the priming pellets in most of which are quite easily cracked or broken; the softer and thinner the priming cup is, the more desirable it becomes to have a priming punch that fits the primer. With a hard stiff primer almost any priming punch, whether flat or concaved will push the primer in satisfactorily because the 279
pressure required to seat the primer is less than that required to deform the cup. With primers having soft thin cups, of which there are many on the market, all of which are crowned or rounded on top, pressure applied with a flat punch will flatten the center of the primer and may (but will not necessarily) crack the pellet inside. On the other hand, if a punch is used with a deeper concavity than the contour of the primer cup, the pressure will be applied at or near the edge of the cup and it may push the edges down at a greater rate than the remainder of the primer, leaving the crown projecting slightly above the head of the cartridge case when the primer is seated to the bottom of its pocket.

There are two methods of governing the seating of primers. One is by the sense of touch, wherein it is possible to feel the primers seat against the bottom of the pocket. This method is practicable with light hand tools and with miscellaneous cartridge cases it is one of the best, if not the best, method of doing the work because the operator knows by the sense of touch when each primer is properly seated, regardless of any little differences in the force required to accomplish this from one cartridge case to another. Any slight marking of the primer cup by the punch is not likely to do any harm, but if there is any considerable marking of the cup because of an improperly shaped primer punch, the remedy is to get a different shape of punch if of the interchangeable type and if not to use a different brand of primer which is harder and stiffer and will resist this deformation.

The second method of seating primers is similar to that used by ammunition manufacturers; namely, a priming punch which is adjustable and whose travel can be definitely limited. A reloading tool equipped with such a punch will only do its best work when the punch is properly adjusted and when the cartridge cases all have primer pockets of uniform depth and are supported in such a way that 280
the bottoms of the primer pockets will always be positioned at a uniform distance from the primer punch. If miscellaneous cartridge cases are used or the travel of the primer punch is not properly limited, such a tool would defeat its own purpose for while it might exert the proper pressure and seat some primers very nicely, others could be compressed too much or else not solidly seated to the bottoms of the primer pockets.

The importance of seating primers properly has been gone into thoroughly in the chapter on primers, but as seating primers is one of the most vital, if not the most vital operation in loading or reloading ammunition, some repetition is permissible. As far as the ballistics of the ammunition are concerned, the reloader can only use primers as he gets them and can do nothing about any faults in ignition that may be due to the primer itself. While as igniters some of our present primers leave a lot to be desired, they can in general be classified as good, if they are properly seated, but there are some of them that will not be good if they are not seated with care.

The anvils must be in contact with, and consequently firmly supported by the bottom of the primer pocket. Failure to seat them to the proper depth, or to seat them with so much pressure that the primer pellet is broken inside of them, will adversely affect the accuracy of the ammunition, and don't get the idea that just because a primer punch fits the crown of a primer that the primer can be rammed in without consideration of the force applied to it. If the anvil is not properly supported or the priming pellet is damaged, the flash from the primer will be different from those that are properly seated. The flash will usually be deficient, but in some primers may actually be excessive. This will cause a difference in the initial ignition of the powder charge and the rate of burning, which in turn will affect the barrel vibration and barrel time of the bullet; that is, the time it takes the bullet to get out of the muzzle of the gun and will cause the bullet 281
to leave at a slightly different point in the cycle of vibration of the muzzle, which may either throw the shot up or down. Wild shots in a group are usually attributed to defective bullets or variations in powder charges, but the reader would be surprised to see some of the things that an improperly seated primer can do.

Many reloading tools combine the operations of expelling fired primers and seating new ones. This is unsound practice but is no reason for condemning a reloading tool providing its design permits the two operations to be separated. The only trouble is that most of these tools have a tremendous leverage available for seating the primer. Furthermore, these tools are for the most part of heavy construction, making it very difficult for the operator to "feel" the primer when it arrives in contact with the bot-

tom of the primer pocket and it is necessary to use such tools with great care in the priming operation if material fluctuations in the muzzle velocity are to be avoided.

Resizing Cases.

Some bench reloading tools or machines are provided with means for resizing cartridge cases full length. This is a great convenience where the cartridge cases must be resized and is a curse where they should not be, because the poor novice whose knowledge of reloading is quite probably limited to the directions he gets with his reloading tool, religiously pumps his cartridge cases in and out of the resizing die because the directions for operating the tool tell him to do it. Sometimes the resizing of the cartridge case is coupled up with the decapping operation. This is fine for reloading military ammunition where the reloaded ammunition must be interchangeable in a number of different guns and where the cartridge cases must be resized whether they ought to be or not, but for the individual reloading for one gun, the idea is not so hot. The danger of head separations from this cause has been gone into in Chapter One under the subject of resizing cartridge cases, but in addition, resizing the cases destroys the perfect fit of the case in the chamber that was attained by 282
firing it. But a reloading tool is no more to be condemned because it combines these two operations than because it combines the operations of expelling fired primers and seating new ones, as it is usually possible to adjust the decapping punch downward so that the primer is expelled before the cartridge case is forced completely into the resizing die, permitting the neck of the case to be resized and possibly causing some slight reduction of the forward part of the case, which does no harm.

Whatever the procedure is, all the cartridge cases should be treated alike. When an unresized cartridge case is put into a chamber, the case is to all intents and purposes in intimate contact with the chamber walls. On the other hand, a cartridge made up with a resized case will fit in more or less loosely in the chamber and when fired the gasses must perform the work of expanding the case to the limits of the chamber and forcing out the air between the case and the chamber, this air having a sort of cushioning affect. This is not of serious consequence, but any reloader who wishes to get the best out of his reloaded ammunition must bear in mind that uniformity is the very essence of accuracy and everything possible should be done to keep barrel time and barrel vibration uniform.

Muzzle or Neck Resizing. This operation is not of much importance except as an aid to holding the bullet. It is divided in two parts, the reduction in diameter of the outside of the case neck and the subsequent expansion of the inside to the proper diameter or dimensions for the bullet. These two operations are frequently combined in reloading tools by the simple expedient of having the expanding plug and resizing die assembled in such a way that when the reduced neck is withdrawn from its die it is pulled over the expanding plug. This is O. K. but a better job can be done by divorcing the two operations and expanding the mouth of the case to a diameter that will permit the bullet to enter freely for a short distance. This
283 is especially desirable when seating cast bullets, as it absolutely eliminates the possibility of shaving metal off the side of the bullet and furthermore, insures that the bullet will start straight into the neck of the case. This is explained elsewhere. This method of seating bullets cannot be carried out if the operations of reducing the neck and expanding it are combined. If an expanding plug is used that is large enough to open the mouth of the case sufficiently so that a bullet may be entered easily, the expansion will exist throughout the length of the neck which has been pulled over the expanding plug and the neck of the case will not hold the bullet at all.

Some reloading tools that do not support the body of the case while the neck is being resized have a tendency to size the necks slightly off center. This may be due to variations in thickness or hardness around the case neck aggravated by lack of support in the tool. It is not a desirable condition but it doesn't have any appreciable affect on accuracy unless under some exceptional circumstances. This may sound "fishy" to the theorist who argues that if the bullet is not concentric with the body of the cartridge case it will not be in line with the axis of the bore. As a matter of fact, if the bullet is concentric with the body of the cartridge case it will not be in line with the axis of the bore unless the cartridge case is a perfect fit in the chamber. If the fired cartridge case will go in the chamber before the neck is reduced it will go in afterwards, regardless of how the neck is reduced. As has been pointed out above, when a cartridge is fired in a normal chamber having a tolerance of several thousandths of an inch, the gasses expand the case to the limits of the chamber at an early stage in their development and before the bullet commences to move forward. This leaves the bullet temporarily suspended and without support and it is purely a matter of chance as to just how it "whops" up against the throat of the rifling when it moves forward regardless of whether it is concentric with the body of the case or not.

284 Regardless of the exact methods used to reduce and expand the necks of cartridge cases, all reloading tools provide some means for doing this and doing it satisfactorily. The exact method used is largely a matter of preference. Resizing the necks of cartridge cases is advisable in loading rifle cartridges and is an absolute necessity when loading them with jacketed bullets. Many jacketed bullets have no cannelures in which the cartridge case may be crimped and if they do have they are usually so shallow that the expanded mouth of a fired cartridge case cannot be crimped on to them securely enough to hold them in place with certainty. Lead bullets can usually be held in place by the crimp alone and sometimes with beneficial results as we will see later, but generally speaking the operations of resizing and expanding necks of cartridge cases should be performed on rifle cartridges.

Chamfering Case Mouth. When cartridge cases are trimmed to length during their manufacture they are usually cut off square on the ends. As the cutting is done from the outside towards the center, the inside edge of the mouth of the case is left quite sharp. As the cutting tool becomes dull a burr is set up on the inside of the case

mouths. If these cases are to be loaded with lead alloy bullets, this burr is removed by a chamfering or bevelling cut to permit the entrance of the bullet without scraping or shaving metal from the side of it. This operation is considered unnecessary on cartridge cases that are to be loaded with jacketed bullets because the danger of deformation of the bullet is not present, inasmuch as the bullet jacket is practically as hard and indeed sometimes harder than the cartridge case. In reloading ammunition, cartridge cases that were originally loaded with jacketed bullets are frequently reloaded with cast bullets and it is advisable for the reloader to examine his fired cases and those that are not properly bevelled on the inside edge should be so bevelled or chamfered that there will be no danger of the sharp inside edge of the mouth deforming the bullets when they are seated. A sharp knife is about as good as any- 285
thing for this purpose or a reamer may be used.

This little operation, which is very simply performed with any sharp instrument, doesn't pertain directly to the use of reloading tools proper, which is the subject of this chapter. Nevertheless, it has a great deal to do with the satisfactory seating of bullets and consequently with the results obtained with any reloading tool.

Crimp Removal. Another little detail that does have a great deal to do with the reloading tool is the matter of the removal of the remaining crimp from fired cartridge cases. Not all, but the majority of commercial or sporting cartridges are crimped; that is, the mouth of the cartridge cases are turned into a groove in the bullet to aid in holding it in place. Crimping cold works the mouth of the case, hardening or stiffening the brass slightly. As has been pointed out, when a rifle is fired the cartridge case is expanded to the limits of the chamber. Whether the pressure and the time for which it is exerted on the case is sufficient to flatten out the crimp entirely, I do not know, but if the gasses do this, it is certain that the hardness and resilience of the crimp causes it to spring back part way after the pressure has dropped, and fired cartridge cases that have been crimped are usually found so small at the mouths that new bullets will not enter them. This crimp must be removed and furthermore, it should be removed before the cases are chamfered. Reaming this crimp out is a makeshift, and repeated crimping and reaming to remove the remaining crimp after firing will eventually shorten the cases. This in itself is not harmful, in fact it isn't a bad idea on rifle cartridges because such cases, when fired with heavy loads, have a tendency to lengthen. However, the evil lies in the fact that the cases become of unequal length and this in turn promotes uneveness in the crimping when they are reloaded.

The proper way to remove remaining crimp is by bending it out by forcing the case against a cone shaped plug or shoulder. Some reloading tools lack any means for per- 286
forming this operation and their design is such that they cannot perform the job well at all, but it can be done quite satisfactorily and rapidly by standing the cases on their bases on a bench or table, inserting a tapered plug successively in the mouths of each cartridge case and striking the upper end of the plug a light, sharp tap with a stick of wood. A few trials will serve to show how hard to hit the plug without flaring the mouths of the cases excessively, although a slight flare is not objectionable. Any object of convenient size and shape can be used for this purpose as the sole function is to get the crimp out of the way so that a new bullet can be seated and there is no need for any complicated apparatus to do it. This little operation also aids in removing dents and at least partially trues up the mouths of cases that have been bent. The common cylindrical form of expander is worthless for removing the crimp; with it the crimp is pushed back while the plug is entering and being withdrawn from the case, but as soon as the plug is out, the crimp springs back nearly to its former position. If the expanding plug has a shoulder on it against which the mouth of the case can be forced in the expanding operation, it makes a very convenient way of doing the job, but unfortunately all reloading tools cannot use a plug of this type.

Powder Charging.

The necessity for uniform powder charges and the methods of weighing and measuring them are taken care of elsewhere in detail, and no further space need be given to it here except to say that for best results the powder measure should be entirely divorced from reloading tools or machines. Factory ammunition is charged with powder by mechanical means, but we have already seen that unrelenting vigilance and inspection are necessary in order to do this successfully. The affect of variations in powder charges is to cause variations in muzzle velocity, even when the ignition is uniform.

287 All reloading tools have a die, punch, plunger or screw which serves to seat the bullets in cartridge cases, with the exception of some special loading dies on hand tools made for special cartridges. These bullet seating punches are adjustable so that the depth of seating of the bullet can be accurately controlled. These seating punches may be roughly classified into two general types: those that seat bullets from their points and those that seat from the ogive, or the curved or tapered portion of the bullet.

The ones that seat from the point will give greater uniformity of depth of seating, as they will seat the bullet exactly the same distance from one cartridge to another. Those that seat from the ogive will not do this because there is apt to be some slight differences in the curvature of the ogives of bullets. This is especially true of jacketed bullets and because of variations in the bullets there will be some variation in the over-all lengths of the cartridges in which bullets are seated by this method, which means that there is some variation in the depth of seating of the bullets. As in all other operations in making ammunition, a certain tolerance is permissible in the bullet seating depth and both types of seating punches can be considered as satisfactory, even though point seating is slightly preferable.

It is advisable but not always necessary, to use a bullet seating punch or screw that conforms closely to the shape of the bullet being seated. This is especially true when seating cast bullets. All of the reloading tool manufacturers can furnish bullet seating attachments that are satisfactory for use with any one of the many cast bullets that are avail-

able, regardless of who they are made by. If an improper bullet seating punch is used with a cast bullet it will cause some slight marking or deformation of the bullet nose or point when the bullet is seated, but this is seldom sufficient to be of practical importance as far as the flight of the bullet is concerned. However, in ordering these items or in ordering your reloading tool the purchaser should specify what bullet he intends to use in it and if it is a cast bullet 288
he should give the name of the manufacturer of the bullet mould and the manufacturers complete number for the bullet. If there are any letters connected with the number, be sure to give those also.

Seating Depth of the Bullet.

Most modern tables of charges give, in addition to the weight of charge and other pertinent information, the depth of seating of the bullet that was used to obtain the ballistics shown in the table. This depth of seating may be expressed in terms of the actual distance that the bullet is seated in the neck of the case, or in the over-all length of the cartridge. The writer prefers the latter method, because cartridge cases and consequently cartridge case necks are not all of a uniform length. If the bullets are all seated to a uniform distance by measurement on the bullet itself, the bullets will be at slightly varying distances from the bases of the cartridge cases. On the other hand, if the over-all length of the cartridge is taken as the unit of measurement, the bases of the bullets will be at a uniform depth regardless of any little differences in the length of the case necks. The variations in cartridge case lengths are normally small but they lengthen out to a greater or lesser extent from repeated reloading and must finally be trimmed or reamed back or the mouths of the cases will butt into the forward shoulder of the chamber. Under ordinary conditions the difference in the relation of the base of the bullet to the powder charge, or the capacity of the cartridge, as between measuring the actual seating depths of the bullets and the over-all depths of the cartridges, will be slight indeed, but when we work in the other direction we find another factor.

If the cartridge cases are of different lengths and the bullets are seated to a uniform depth according to the measurement on the bullet itself, the bullets will be at varying distances from the throat of the rifling. On the other hand, if the measurement is taken by over-all length on the cartridge, the bullets will be a uniform distance 289
from the throat. If one bullet moves from .004" or .005" or possibly more than another before coming in contact with the rifling, it will strike a harder blow than it will in moving a shorter distance and will certainly have some varying affect on the barrel vibration. Therefore, by measuring the over-all-length of the cartridge we have a slight advantage in both directions.

The depth of seating of bullets as given in tables of charges need not be adhered to except when loading the heaviest recommended charges. Under such circumstances the seating depth given in any table should not be exceeded. It may be decreased with beneficial results for reasons that will be discussed later. With reduced powder charges an increased seating depth is permissible, but seldom desirable.

If the mouths of the cases have been opened up sufficiently so that the base of the bullet can be entered into the neck for say 1/10" or more with the fingers and the case mouths have been chamfered or bevelled, cast bullets can be seated perfectly all the time. If on the other hand, the expander used leaves the neck of the case a size that requires the bullet to be forced in, the chances are not so good, for in this condition the base of the bullet must be placed against the bevelled mouth of the case and twisted a little to make it stick in place; perched in this precarious manner there is no telling what may happen to it when it is put into the loading chamber of the tool. As often as not the bullet is dislodged by contact with the inside of the chamber and is dependent upon Lady Luck to steer it into the mouth of the case again. Flaring the mouths of cartridge cases helps to avoid trouble when the case necks are undersize.

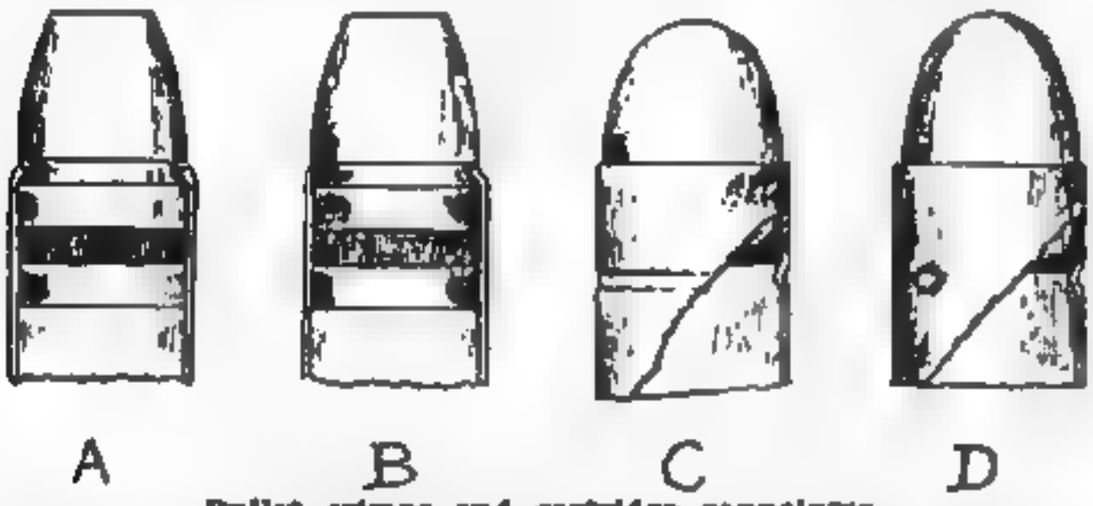
Cannelures.

Some cartridge case necks have cannelures in them; that is, a groove rolled in around the neck of the case. Factory ammunition is loaded with the cases in a vertical position
290 and these cannelures are put in to limit the depth of seating of the bullet. Occasionally, cases that happen to be thin at the neck will be so large that the bullets would drop right down on to the powder if there were no cannelures there to stop them and such cartridges would have to be scrapped. In reloading cannelured cases it is desirable to use bullets that will give the cartridge the proper over-all length, without forcing the base of the bullet beyond the cannelure. If bullets are seated so that their bases go in beyond the cannelure the cases will be bulged at the cannelures and the ammunition will probably not chamber. This trouble can be remedied by placing the necks of the loaded cartridges one at a time on a flat strip or plate of steel and rolling the cartridge with another flat piece, at the same time applying considerable pressure. Between the rolling and the action of firing, the cannelures will usually be flattened out sufficiently with one or two reloadings so that they will cause no further trouble.

Crimping.

When ammunition for any arm is reloaded without resizing the case necks sufficiently so that the tension of the case neck alone will hold the bullet in place securely, the cartridge cases must be crimped or turned over onto the bullet to hold the latter in place. Cartridges for use in rifles having tubular magazines must be crimped and crimped quite heavily and it is desirable to have the bullets in such cartridges seated friction tight as well. When cartridges are inserted into a tubular magazine they lie end to end and compress the magazine spring, which exerts pressure on the column of cartridges to force the rearmost cartridge back into the carrier when the latter is in its lower position. When the rifle is fired the column of cartridges does not recoil at the same velocity as the rifle as they are not held rigidly in place, being supported at the front end by a compressible spring. As a result, a considerable part of the energy of recoil is stored up in the magazine spring which subsequently exerts this stored up force on the

column of cartridges, driving them to the rear. This force 291
tends to shove the bullets back deeper into the cartridge cases and the crimp helps to resist this. In uncannelured cases, the crimp may be insufficient to keep the bullets from being forced back into the case. This is especially true when the magazine is nearly empty as the reduced compression of the magazine spring permits a greater move-



Bullet crimps and cartridge cannelures.
A—Bullet crimped into mouth of case. B—Imperfect crimp, deeper on right side than on left. C—45 Auto case, with square shoulder at mouth and case cannelured to prevent bullet from seating too deep. D—Same as C except case is indented instead of cannelured.

ment of the cartridge column and consequently the cartridges attain a higher velocity of movement in the magazine under the impulse of the spring.

An old method of aiding in checking the receding of the bullets into the cases is to indent the neck at several points just in the rear of the location of the bullet bases. Of course, if the cases are cannelured this need not be done, but if the case has no cannelure or if the cannelure is shot out and experience shows that the bullets do recede into the cases, it is about the only remedy that can be applied.

Indenting case necks has an objection when cast bullets are used. A cannelure will support the base of the bullet all the way around, giving a uniform distribution of the stress on a bullet base. Indentations are so localized that when a bullet is forced back against them, nicks or depressions are put in the bullet base at the points of indentation. If the condition is bad enough, it will have a slight detri-
mental affect on accuracy, but as most tubular magazine 292
rifles do not develop the highest degree of target accuracy anyway, this is probably of little practical importance. In any event, a good heavy crimp will help to prevent the bullets from receding.

Revolver and automatic pistol cartridges must be crimped quite heavily, as the resistance offered to the forward movement of the bullet by the crimp is an important factor in promoting proper combustion of the powder charges. The one noteworthy exception to this rule is the .45 Colt Automatic pistol cartridge. This cartridge should *never* be crimped, as it is positioned in the chamber of the pistol by the square forward edge of the case contacting a corresponding shoulder in the chamber.

Crimping is also advisable in rifle cartridges using light charges of quick burning powders and is sometimes desirable with heavier loads in single shot rifles and repeating rifles having box magazines.

In all reloading tools, crimping is accomplished by forcing a coned or tapered shoulder in the loading chamber against the mouth of the cartridge case, or vice versa. This is usually accomplished at the same time that the bullet is seated to the proper depth. As most reloading tools have that portion of their loading chambers that receive the neck, made large enough to handle cartridge cases that have been expanded by previous firing and have not been resized, these chambers are slightly over-size for cases the necks of which have been resized. This frequently causes a resized case to slide a little bit to one side or the other, causing the crimp to be turned over a little more heavily on one side than the other. This unevenness in crimping, while not desirable, does not have a serious affect on accuracy as is commonly supposed, but the unevenness can be at least overcome to some degree by partly crimping the cartridge, then turning it around 180 degrees before completing the crimping. The condition is found alike in the straightline, as well as the tong types of tools.

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Water-proofing Ammunition.

Ordinarily, there is no object in water-proofing handloaded ammunition. Such cartridges are usually fired within a relatively short space of time after being loaded and under conditions where water-proofing would be unnecessary. However, if one wishes to water-proof his ammunition, it may be done as follows.

After the cases are primed, put a drop of lacquer on each primer. Ordinary quick drying, clear lacquer may be used. It can be applied with a tooth-pick or any other slender stick which, when dipped into the lacquer, will pick up a drop. The excess lacquer should be wiped off by rubbing the head of the case across a piece of cloth laid flat on a table, after the lacquer has flowed all around the edge of the primer.

This lacquer around the primer should be allowed to dry thoroughly before seating the bullets. This is especially necessary with short cartridges where the bullet occupies a considerable part of the space in the case. If bullets are seated in such cases before the lacquer is dry, the bullet, acting as a piston, will compress the air in the case, forcing it out around the primer and breaking the seal.

If the mouths of the cases are to be water-proofed also, they must be resized so the bullets will be held friction tight. After the cases are charged with powder, a thin coat of lacquer should be applied all around the insides of the necks and allowed to *partially* dry before the bullets are seated. As the bullets are pushed down, their bases will shove the gummy lacquer along, forming a thick seal around the base of the bullets. A bit of actual experience is necessary here in order to do the job right. Do not use so much lacquer that it will flow or run down on the powder and do not seat the bullets too soon after applying the lacquer, as it may still be soft enough to run down after being scraped up and formed into a seal by the bullet bases.

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Inspection.

It may appear to some readers that my many comments on inspection are exaggerated, but they are not. Not much mention of its importance has previously been made in books on handloading because, until quite recently, loading tools performed their operation one at a time, or in such a

way that the reloader could always see just what was going on, readily observing any defects in the components and loading while doing the work. In other words, the inspection took place without conscious effort or thought on the part of the individual.

In recent years, a demand has arisen for loading tools which will load ammunition rapidly and a number of new tools have made their appearance on the market which combine the necessary operations so as to produce ammunition more *rapidly*, regardless of any other considerations. Now let's take a look at this demand. Does it arise with people well informed on ammunition and handloading? It does not! It comes from the rank and file with a superficial knowledge of handloading or none at all, folks who have a yen to spend less time reloading ammunition and more time shooting it, which is a very good idea indeed if carried out intelligently. Whether some of the newer tools and machines have been turned out by mechanics or firms with the business acumen to take advantage of the sucker demand, or by those with no more knowledge of handloading than the demanders, I don't know and care less. Neither do I mean that every loading tool that comes out is bad just because it is new. As a matter of fact, most of them can be used with safety and satisfaction if the user will observe the fundamental principles of cartridge loading, the first and most important of which is *inspection*.

In the manufacture of new ammunition with modern precision machinery it might appear that the product would flow through the machines and come out perfect with a little watchfulness and gaging here and there, but it will not. Taking the .30-06 military cartridge as an example, the number of manufacturing operations varies a little with 295
different manufacturers but there are about 110 of them and they all have to be inspected. Of the total labor cost of manufacturing this cartridge, making the clips, bandoleers, boxes, tin liners, packing the ammunition, sealing the cases and marking them, 15% is for inspection. The cost of inspecting the ammunition is about 55% of the labor cost of making the cartridge case alone. If the reader were to go through an ammunition factory he would probably come out with the impression that about 50% of its employees were inspectors, and these inspectors that one sees devoting all their time to such work does not include the gaging and watchfulness of the machine operators themselves.

In reloading ammunition, safety depends largely upon cartridge cases which have been strained more or less by previous firing and it is necessary to pay attention to inspection *all along the line*. This necessity becomes more important as the power of the reloads increases and any reloading tool should be used in a way that will permit careful and continuous inspection, regardless of how slow the operation of the tool becomes in so doing. Remember, it is brains rather than hands that make safe and satisfactory ammunition. If you do not use the brains, you may suddenly find yourself with half a handgun missing from above and a couple of fingers off from below, or you *may* come out with an eye or two gone and a puss full of brass and steel fragments. Intelligent handloading just can't leave inspection out.

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Chapter Thirteen

REVOLVER AMMUNITION.

Handloading ammunition for revolvers is the same as loading for any other kind of a cartridge from a mechanical standpoint but like loading any other cartridge, doing the work intelligently depends largely upon a consideration of the type of arm the amunition is to be fired in. Everyone knows what a revolver is; a firearm having a frame which carries the lock mechanism, into which a barrel is fitted, with a cylinder in which the chambers are reamed and which rotates so as to align the successive chambers with the barrel as the arm is fired. Due to the separation of the chambers from the barrel, there is a considerable amount of gas leakage between the barrel and cylinder each time the arm is fired.

This type of firearm is of three general designs. The first type has a solid frame and the cylinder is attached to it by the pin or rod on which it rotates and can only be removed by first removing this rod. The Colt single action Army model and the miscellaneous lot of low priced revolvers of different makes are examples of this class.

The second type is the so-called "top break" in which the frame is divided into two parts, the top strap and front of the frame carrying the cylinder pin, cylinder and barrel; the frame being hinged at the front end (usually at the lower part of the frame). The rear part of the top strap carries a latch for locking the gun when closed and the arm is loaded by unlocking the latch and tipping the barrel downward, an action which usually causes the ejection of any cartridges or cases that may be in the chambers and exposes the chambers for loading. Some of the older Smith & Wessons, the British Webley and a great variety of cheap and moderate priced revolvers are examples of this type.

297 The third class, which is confined chiefly to modern Colt and Smith & Wesson revolvers and cheap foreign imitations of them, has a solid frame to which the barrel is permanently attached, while the cylinder and its pins are mounted on a crane which can be swung out to one side when unlocked.

Each of these types has its advantages and disadvantages, which need not be discussed here, but all of them possess peculiarities that are not found in any other type of arm and all of them must have a much greater amount of head space, or clearance between the heads of the cartridge cases and the standing breech, than would be permissible in a rifle. This is necessary to permit free rotation of the cylinder and smooth functioning of the gun. It is permissible in a revolver and is possible only because of the relatively low pressures that are developed by revolver cartridges; the limit of which is nominally considered as 15,000 pounds per square inch, but which runs to 20,000 pounds in some of the high speed cartridges and to nearly 40,000 pounds in the .357 S. & W. Magnum. The latter, by the way, had to be specially constructed to handle cartridges developing such high pressures.

When a revolver is discharged, the cartridge fired is

driven forward by the blow of the firing pin and subsequently is forced back sharply against the standing breech by the pressure developed within it. The remaining cartridges in the chambers are also thrown back violently by inertia. The more modern revolvers have a separate piece in the form of a bushing or plate forced into, or dovetailed into the rear of the frame, or standing breech, having a hole through which the firing pin or hammer nose passes. 298
This separate, replacable piece is put in because this hole is subject to wear and if enlarged too much the primer, weakened by the blow of the firing pin, may pierce or blow out, blowing the hammer violently back to its rearmost position, with damage to the mechanism and possibly minor injuries to the shooter's hand.

In the side swing revolvers, this recoil plate takes the form of a small disc forced into a recess in the frame itself. This disc must take the thrust of the set-back of the primer and in the case of small cartridges, such as the .32 S. & W. and similar sizes and to a slightly lesser extent with the .32/20, practically the entire thrust of the cartridge head. If cartridges are over-loaded, their continual use is liable to set the recoil plate back, permitting the primers to project above the heads of the cartridge cases, thereby impeding rotation of the cylinder. For this and other reasons, the common belief that the strength of a revolver and its ability to handle heavy loads is dependent entirely upon the strength of the cylinder is erroneous.

The general operating principle of a revolver is as follows: The cylinder carries a ratchet at its rear end in close proximity to the frame and is rotated by means of a pawl or "hand." The hand in single action guns is attached to the hammer, in double action guns to the trigger. This hand projects through a slot in the rear of the frame, to one side or the other of center and is thrust upward by the action of cocking the gun (or in the case of double action guns by pulling the trigger) and the upward thrust of the hand causes the cylinder to rotate. The outside of the cylinder has a series of equally spaced depressions, or bolt stops, milled in it, equal in number to the number of the chambers. Projecting through the bottom of the frame is a small movable piece or lug called the "bolt" which, at the proper time, comes up and enters one of these depressions in the cylinder, acting as a stop or lock to position a chamber in line with the barrel and also with 299
the hole in the recoil plate so that the primer will be struck by the hammer nose and the bullet will enter the barrel. The bolt remains in this position from the time the gun is fully cocked until it is fired, and is not depressed or unlocked from the cylinder until the arm is cocked for firing again.

The common belief is that each time a revolver is cocked the uppermost chamber is in perfect alignment with the axis of the bore of the barrel but, unfortunately, this is not exactly true. In Colt revolvers the cylinders revolve to the right. The hand is located as far as possible to the left of the center of the frame and the bolt as far as is convenient to the right of the bottom of the frame. These guns are so adjusted that when the trigger is at its rearmost position, or at the position at which it is when the sear is released and the arm is fired, the hand is exerting pressure on the cylinder, rotating it against the resistance of the bolt. In other words, with the trigger all the way back, the cylinder is locked.

The method of checking the alignment of the chambers with the barrel, when the cylinder is in position for firing, is to pass a plug gauge that fits the bore closely through the barrel and into each chamber. If the plug passes freely into the chambers, the alignment is considered correct. It should be borne in mind, however, that this plug is of bore and not groove diameter. Therefore, a chamber might be out of alignment by as much as the depth of one groove and the plug would still enter freely. Furthermore, the throats in the cylinders, or that portion just ahead of each chamber which acts as a guide to the bullet before it enters the barrel, are invariably of larger diameter than the groove diameter of the barrel. It will, therefore, be seen that it is possible for a chamber to be several thousandths of an inch out of alignment and still pass the factory test.

In Smith & Wesson revolvers the mechanism is so ad-
300 justed that when the cylinder is in the firing position there is a slight amount of play in it. This play is apparently purposely left to give the cylinder itself a chance to compensate for any small variations in alignment when the bullet is passing from the cylinder into the barrel. Whether there is time for any such compensation is questionable, but certainly the principle is not harmful even if the practical effect is not apparent.

I realize that many revolver shooters will be horrified to learn that their cylinders do not necessarily line up precisely with the barrels of their revolver, but the little variations which do exist should not be considered so much in the light of defects as merely limitations that are necessary in the particular type of arm.

Anyone can very easily examine his own gun for alignment if he wishes to verify these statements. All that is necessary is to cock the gun, holding its trigger and the hammer back. At the same time, point the gun towards a strong light or insert a small flash light in the muzzle, then look through the hole in the recoil plate from the rear. By looking past the hammer on either side, it is possible to see both sides of the bore through the chamber. If there is any play in the cylinder it can be worked back and forth so that its relation to the barrel may be seen. If you do this little stunt, don't throw a "cat fit" over what you see, or complain to the manufacturer that your gun is no good. The revolver is an intricate piece of mechanism and it is remarkable that the manufacturers are able to get the cylinder alignment as good as they do, without making the cost of the guns prohibitive.

The revolver is essentially a short range weapon. Fired with one hand, unsupported and with such a short sight radius, no one expects to get 1" or 2" groups at 100 yards, nor could they, except by luck, no matter how accurately a revolver might be made. The longest range at which one is ordinarily used is about 50 yards and all revolver targets have bullseyes and counting rings very much

larger than rifle targets used at similar distances. Yet in 301
spite of the limitations in the design of revolvers, and the minor tolerances in their working parts, they will shoot with excellent accuracy provided the capabilities of the shooter are equal to those of the gun.

However, to further assuage the feelings of those individuals who may have believed that the chamber and barrel alignment of revolvers is the very essence of perfection it may be stated here, leaving the details until further along, that even though cylinder alignment IS perfect, it is a matter of chance whether or not a revolver bullet passes from the cylinder into the barrel with its axis in perfect alignment and coincident with the axis of the bore.

Bullet Jump.

As the chambers of a revolver are entirely separate from the barrel, it is impossible for the bullets to be in close 303
contact with the rifling before they are fired. The bullets must jump forward at a considerable velocity and more or less without support before they strike the rifling. They also must be seated deeply enough in the cases so they will not project beyond the front ends of the chambers, as this would prevent the cylinders from rotating.

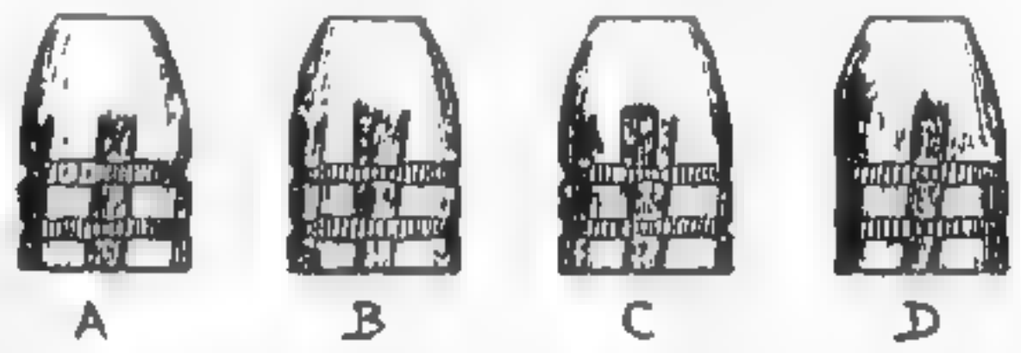
The throats of the chambers are always larger in diameter than the groove diameter of the barrel and normally, revolver bullets do not upset or expand much when they are fired. The degree of upsettage, if any, depends upon the hardness of the bullets and the nature of the powder charge used behind them, but as a general rule solid base bullets do not expand sufficiently to fill the throat, consequently the bullet must pass from the chamber into the barrel more or less unsupported. The accuracy of the arm depends largely upon how well the bullet is guided between the time it leaves the case and enters the barrel. If an attempt were made to load bullets that were as large in diameter as the throats of the chambers, the resultant cartridge would in most instances be so large at the neck that the ammunition would not enter the chamber. Furthermore, this diameter might be so much greater than the 302
groove diameter of the barrel that dangerous pressures might develop from attempting to force such an oversize bullet into the barrel.

Bullet Slippage.

The considerable jump that a revolver bullet must make before it comes in contact with the rifling permits it to attain a rather high velocity, consequently its contact with the lands and grooves is accompanied by a considerable shock. Due to this velocity that it attains while moving forward through the throat of the chamber and the barrel cone, it has a tendency to drive straight forward into the barrel, ignoring the rifling. Normally, the resistance offered by the inclined driving edges of the lands cause this forward movement to be overcome quickly, and under conditions of proper loading the bullet usually attains its normal rate of rotation before it has entered the rifling for its entire length. These "slippage" marks can be seen on almost any of the bullets illustrated in this chapter of the text. The amount of slippage depends upon the hardness of the bullet, its velocity, the nature of the rifling and the relation between the bullet and bore diameters.

If a soft, short revolver bullet is fired at too high a velocity these slippage marks will extend all the way back to the base of the bullet. If in addition the barrel is a short one, the bullet may never attain its proper rate of rotation. It is doubtful if this is true in a barrel of normal length, say from 4" up, for after all a bullet depends for its rotation only upon one edge of each land of the rifling and even though a short bullet does show slippage clear to its base, it may still acquire a normal degree of rotation because of the resistance offered by the driving edge of the lands. In actual practice, however, bullets which show an abnormal degree of slippage do not perform well and it is advisable not to use short bullets for so called high velocity loads. When using such loads the bullet alloy should be stiffened or hardened. This hardening of the bullets when 303
used with the heavier loads has a three-fold beneficial effect. The slippage is reduced. There is less tendency for the bullet base to upset excessively when passing from the cylinder into the barrel. There will be less tendency for the barrel to lead than if a softer bullet were used. All of these things contribute to good accuracy.

As a matter of fact, the normal jump of a rifle bullet may also be sufficient to cause some slippage, but as rifle



Results of slippage, tipping and shaving of bullets.
A—Fired bullet showing perfect rifling marks, no indications of tipping, slippage or shaving. B—Bullet showing slippage. Note that left hand edge of rifling mark on bullet is straight, showing that bullet plowed straight forward into rifling for some distance before taking up rotation C—Bullet showing two sets of rifling marks with different angles, indicating that bullet was badly tipped when it entered bullet seat, but later straightened up. D—Bullet badly shaved on left side as a result of poor alignment of revolver cylinder.

bullets normally jump a much shorter distance than is the case in revolvers and because of the use of slower burning powders, they probably do not acquire as high a velocity over the short distance of jump as a revolver bullet. Therefore, the effect of slippage in a rifle is negligible, especially with jacketed bullets, and can practically be eliminated by seating the bullets out of the cases far enough so that they will be in contact with the rifling before the cartridge is fired.

In revolvers, the general rule is to use moderate loads with short or soft bullets and longer and harder bullets for the heavier loads.

Very rarely a revolver barrel will split at the rear end but this can be caused by the excessive upsetting of a soft 304
bullet just as well as it can by a jacketed bullet and is not likely to happen at all with a cast bullet made from a fairly hard alloy.

Bullet Diameter.

In rifles the groove diameter of the barrel may be used as a guide for the proper sizing of cast bullets, but with the revolver, consideration must also be given to the throat;

as a consequence, it is common to find that revolver bullets are smaller than the throats of their chambers and sometimes several thousandths of an inch larger than the groove diameter of the barrel. It is disadvantageous to use bullets that are much above the standard size of revolver bullets loaded by the commercial ammunition manufacturers. These bullet diameters have been arrived at as the result of long experience in many different arms and while some departure from these standards is permissible in some individual weapons, it cannot be recommended in general.

Now let us take a look at what happens if an over-size bullet is used. When a cartridge is fired, the cartridge case expands before the bullet has time to overcome its inertia and move forward, because less pressure and time are required to expand the thin case than to move the comparatively heavy bullet. In other words, the case lets go of the bullet first. The crimp, especially if it is a heavy one, may retard the forward movement of the bullet, but probably most of this crimp is forced out by the gas pressure, even though the crimp later springs back part way. As the bullet is at best smaller than the throat or guiding portion of the chamber it is a matter of chance as to the direction and amount of tip that the bullet takes before it enters the barrel. With bullets of standard diameter in modern guns there is not a great deal of tipping, if there was we would not get the accuracy we do; but, even so, the bullets do usually strike on one side of the rifling harder than the other. That this is true can be readily determined by marking the bullets to indicate their positions when fired and examining them after they are recovered. This condition may be aggravated by a slight misalignment of 305
the chamber and barrel, but it occurs with ammunition fired from chambers that are in perfect alignment with the barrel. On the other hand, there are indications that at times a small error in alignment may actually compensate for any slight tipping of the bullet. Now if bullets are sized down to the groove diameter of the barrel, the clearance between the bullet and the guiding walls of the throat of the cylinder, upon which it depends for its alignment, will be increased and the angular entrance of the bullet into the barrel may also be increased.

In determining the proper diameter for revolver bullets, this haphazard movement of the bullet before it comes in contact with the rifling, the relatively large diameter of the throat, and relatively small diameter across the grooves, leaves one between the devil and the deep blue sea, except for the one saving grace that even experienced reloaders sometimes overlook. This saving grace is the standard diameter of revolver bullets—that has been determined upon after years of experience and experimentation. I repeat that this does not mean that the diameters of cast bullets for revolvers should not or can not be varied from the factory standard to meet little peculiarities in individual guns, but it does mean that unless the reloader has had considerable experience with reloading, he will probably get the best results if he sticks to the standard factory diameters.

The question may arise as to how much difference a few thousandths of an inch one way or the other from the standard bullet diameter will make in the accuracy of the ammunition. There is no fixed rule. The difference will usually only be slight and probably not enough to be noticeable to the average pistol shooter—but there is a difference. Comments of this kind are apt to create the impression that a bullet of normal diameter will shoot well, while one of slightly smaller diameter will shoot all over the lot. This is not necessarily the case, but it is true that the
306 difference will be more noticeable with short light weight bullets than with the longer bullets of standard weight. The shorter bullets have more opportunity to tip and their angle of tip will be greater than that of a bullet of normal bearing length. One of the advantages of sharp shoulder bullets lies in their longer bearing length and the lesser opportunity there is for them to tip while passing through the throat, but such advantage as this may give them is more than offset by their miserable ballistic shape.

Leading.

There is another factor to be considered; namely, leading. I have mentioned the subject of leading in a number of places in this book and have quickly steered off from it onto something else. The reason is that I know very little about it. I have been fooling around with the subject and experimenting with it for about 14 years and with all types of weapons and I can't give a definite solution to this problem for any particular type of gun. What works in one gun doesn't seem to work in another, but there is one thing that can be stated quite definitely and that is that the relation of bullet diameter to throat diameter in a revolver has some bearing upon leading. If the clearance between the bullet and the throat are sufficient (and they usually are) gas rushes past the bullet, blowing particles of lead from the edges of the base and the bands; if these particles of lead adhere to the barrel, leading will build up. The bullet diameter is not the whole story and the actual clearance between it and the throat involves the bullet hardness and the powder charge used behind it, and the bullet hardness involves the alloy which also has something to do with the question.

If the reader is inclined to doubt that lead is blown off from the bullet before it enters the barrel, he should examine the outside of the cylinder of his revolver the next time he gets through shooting it. Over the top of each chamber at a distance of about¼" back from the front end of the cylinder there will probably be a distinct and
307 heavy smudge. It may only be a mixture of bullet lubricant and powder fouling, but it usually requires a little rubbing to remove it and oftentimes shows a distinct lead color. The lead is easily rubbed off, but it had to come out between the barrel and the cylinder before the bullet passed into the barrel. The heavier the loads the more pronounced this condition will be.

Before sneaking out from under this subject of leading once more, I would like to say that the condition which frequently occurs in revolvers where a deposit of lead is left around the rear end of the barrel but does not increase appreciably with continued firing, I do not consider leading, nor do I believe any particular attention should be paid to it other than from an experimental standpoint.

When I test a particular gun, bullet, or kind of lubricant for leading, I fire a maximum of 300 shots. That is about as much as a gun is likely to be fired without cleaning in one day and if, after firing 300 rounds, the accuracy is not impaired, I do not consider that the gun is leaded, regardless of any minor deposits of lead that it may have in the barrel. Leading is a practical problem and it is only of importance when it effects accuracy adversely in a comparatively short series of shots. I have very little sympathy for these "nuts" who let out a wail of woe over a few little specks of lead in a revolver barrel that can be taken out with a couple of pokes of a brass wire brush.

Selection of Cases.

The newer so-called high speed or high velocity revolver cartridges are loaded up to pressures of around 20,000 pounds per square inch and such a pressure is too high for absolute safety in a folded head case, when used in an arm having as much head space as a revolver. Solid head cases also have thicker side walls and consequently a somewhat smaller powder capacity than folded head cases of the same caliber. With any given charge the density of loading will be greater in a solid head case than in a case of the folded head type, all other loading conditions being equal. The difference is not great, but anyone wishing to 308
get the best of accuracy should sort out the two types of cases and not mix them in loading or firing.

Resizing Revolver Cases.

Resizing revolver cases full length will make no practical difference insofar as accuracy is concerned but as new or resized revolver cases are usually a pretty free fit in their chambers, a considerable amount of expansion takes place and continual resizing of these cases, which are relatively thin as compared with most rifle cases, will shorten their useful life slightly. If the reloading tool used is one that holds the cartridge case in a vertical position while being loaded, complete resizing of the case or at least resizing of the muzzle end will be necessary, as otherwise there will be nothing to prevent the bullet from dropping freely into the case to too great a depth. If the cases are cannelured and the cannelure hasn't been ironed out enough by previous firing, this will act as a stop for the bullet. As a matter of fact it was for this purpose that cases were originally cannelured, but the trouble with depending upon the cannelure as a stop for the bullet base when loading cast bullets is that there is no uniformity as to the location of cannelures in different lots of cartridge cases; furthermore, the variety of shapes and lengths of cast bullet is so great that it will be a matter of chance as to whether the distance from the base of the bullet to the crimping groove will be the same as the distance from the cannelure to the mouth of the case.

The use of unresized cartridge cases in a revolver is perfectly permissible and is, theoretically at least, desirable but as the bullets must be held in place by the crimp alone, they can usually be rotated with the fingers after they are crimped. Many of the present day cartridge cases are quite soft and after being reloaded a few times, even with normal loads, they are apt to be a pretty tight fit in the chambers and some resizing is necessary.

309 ***Neck Resizing.*** As far as shooting is concerned, reducing the mouths of the cases to hold the bullets friction tight does not possess any particular charm from an accuracy standpoint, but this is not a bad practice by any means, for in addition to the crimp it offers additional insurance against the cases working off from the bullets under the influence of recoil.

Crimping.

Regardless of whether the bullets are seated friction tight or not, revolver cartridges should always be crimped and *crimped heavily* as the resistance of the crimp is necessary to promote proper combustion of pistol powder charges. When a bullet is seated, the lubricant rubs on the inside of the case neck, forming a thin film between the bullet and the case, and the force required to pull the bullet from the case will be less than if the bullet were dry. When the arm is fired it is thrown abruptly to the rear by the recoil and the cases of the cartridges in the remaining chambers, because of their lighter weight and lesser inertia, have a tendency to move to the rear quicker and at a higher velocity than the bullets in them. This sometimes causes the cases to strip off from the bullets slightly with each shot, thereby increasing the over-all length of the cartridges. The condition is usually attributed to the bullets working out of the case, but it is usually the reverse; the cases work off from the bullets. The net result is that sometimes a cartridge lengthens enough so that a bullet projects from the front end of the cylinder far enough to interfere with rotation. This also causes a slight increase in the air space in the case that is not particularly desirable, while the malfunctioning of the arm is an entirely unnecessary nuisance. Proper crimping of the cartridge will prevent this.

To get back to so-called bullet jump or an elongation of revolver cartridges from recoil; this is an important consideration. The only American revolver using a cartridge that is not normally crimped is the Model 1917 revolver
310 or revolvers using the .45 Automatic pistol cartridge. This cartridge is made primarily for the automatic pistol and is positioned in the barrel by the forward edge of the case coming in contact with a shoulder in the chamber. This contact also supports the cartridge against the blow of the firing pin. Revolvers using this cartridge are chambered on the same principle and the clips commonly used in revolvers are for the sole purpose of affording extraction. However, in actual practice these clips many times support the cartridge against the blow of the firing pin.

Anyone who has used the caliber .45 automatic pistol or revolvers for this cartridge has probably at some time or other encountered ammunition having several indentations around the necks of the cases that appear to have been made with a prick punch. As this type of cartridge must be made to serve interchangeably in the revolver and the automatic pistol, at least for military service, it cannot be crimped. The indentations are used in lieu of a crimp to prevent the cartridges from lengthening excessively from recoil, when fired in the revolver. Indentations of this kind are practical in ammunition loaded with a hard metal jacketed bullet but would serve no very good purpose if the

ammunition were loaded with a lead alloy bullet.

In order to check the elongation of this cartridge when fired in a revolver with cast bullets, the writer conducted a test a number of years ago of the following nature and results: Fifty test cartridges were loaded with 5.9 grains of Pistol Powder No. 5 and a 220 grain cast bullet having a single lubrication groove. The bullets were, of course, seated friction tight in the cases. Each of these cartridges had a file mark in the head for identification purposes and each one was loaded in the cylinder with five other loads which were fired. In this way, the test cartridge was subjected to the recoil of five shots. Each test cartridge was measured for over-all length before and after the test and the amount of elongation recorded. The elongation for fifty cartridges varied from .000" to .045", the mean being slightly over .018". The lubricated lead bullets, which 311
incidentally were 10 grains lighter than the service bullet, gave a greater degree of elongation than is permissible in military ammunition, but it is not believed that the elongation which takes place is of practical consequence over ordinary revolver ranges.

The heavier the bullet and the heavier the recoil, the more likely the cases are to strip off from the bullets, but crimping will prevent this fault. With the caliber .45 Automatic pistol cartridge when loaded for use in a revolver, the case can be tightened slightly onto the bullet by means of a crimping shoulder in the tool, although such tightening should not consist in bending the mouth of the case sufficiently to be worthy of the name of a crimp. This stunt will only work on a bullet that has no crimping groove.

Variations in Crimp. Reloading tools will sometimes turn a crimp that is not uniform. The case may be severely crimped on one side and not at all on the other. This is due to several causes. The brass from which the case is made may be slightly softer on one side than on the other, causing it to collapse more easily. Sometimes the case is a little smaller in diameter than the crimping chamber, so it slides to one side and bears harder on one side than the other. The ammunition manufacturer makes cases within very close limits and his crimping dies are made to handle new and uniform cases. This represents an ideal condition; but, in spite of this, the reader would find plenty of factory loaded cartridges with variations in crimp if he were to inspect a lot of ammunition after it came from the machines. True, these variations would be much less than are ordinarily found in handloaded ammunition, which may make it appear that reloading tools are not properly made; but this is not true. The loading tool manufacturer has a harder problem with which to contend than the ammunition manufacturer, because the reloading tools must be made in such a way that they will handle cases that have been *expanded* from firing. For this reason, the 312
reloading tools are made to meet the requirements of the *expanded* case. When *a new, resized,* or only slightly expanded case (from a close chamber) is used in one of these tools, there is a certain amount of play between the case and the parts which guide it. Sometimes the irregularity of crimp that results is very noticeable. The cartridge can be turned half way around and forced against the crimping shoulder a second time to help equalize the crimp if desired. Reloading tools that resize cases in the normal operation of the tool and, consequently, perform their operation on cases of a uniform size, have a little better chance of turning a uniform crimp than others, but a certain lack of uniformity of crimp is inherent in all reloaded ammunition.

If a cartridge could be fired in such a way that the gas pressure would not force the crimp out and *if* there were no throat or guide for the bullet as it left the chamber, the drag of the crimp would, without doubt, cause the bullet to tip more or less. But a revolver cartridge cannot conceivably be fired under such conditions. The gas pressure *does* relieve the crimp and the bullet *is* guided into the barrel, so the amount that the crimp can possibly tip the bullet is limited to the tolerance between the bullet and the throat of the cylinder. An undersized bullet will presumably show the effect of an irregular crimp more than one that is of correct diameter. I say *presumably* because I have never been able to detect any increase in dispersion from this cause from ordinary firing, nor to test any such ammunition in any device that was sufficiently accurate to definitely show that any slight enlargement of a group was due to the crimp. If the reader wishes to try an interesting experiment, load some revolver ammunition without crimping the bullets. Then, with a cold chisel or a screw driver, knock a heavy crimp in one side of the case. Then take the ammunition out and shoot it and see if you can detect any difference in accuracy over your regular product!

The object of these observations on crimping is not to
313 create the impression that poorly crimped ammunition is desirable—uniformity, whether it be the crimping or any other detail of reloading, is and always will be conducive to the best accuracy. On the other hand, it is possible to get an exaggerated idea of the importance of little variations, hence the advice that the reloader of revolver ammunition save himself needless worry over a little irregularity in the crimping of his cartridge.

Revolver Bullets.

Revolver bullets are essentially confined to the lead alloy variety. The *easiest* way to obtain revolver bullets is to buy them and the cheapest place to buy them is from one of the ammunition manufacturers.

The *cheapest* way to get cast bullets is to cast them yourself. You will save money and will have absolute control over the hardness and perfection of your bullets.

Regardless of how you get them, the *selection* of bullets will depend upon the use to which they are to be put. If you are a peace officer who may have to stake his life on a knock-down shot at short range and equally short notice, get the most powerful factory loaded ammunition available and don't monkey with hand loads except for practice. If you belong to the regiment of big game hunters and are interested in revolver loads for use on big game, you will probably want one or another of the so-called "man stopper" bullets (most of which, by the way, never stopped a man). But if, by chance, you belong to the great army of target shooters who persue the elusive bullseye for the sheer enjoyment of the game, you will derive the greatest

enjoyment and success from moderate loads.

The large number of different shapes and weights of revolver bullets for which bullet moulds are obtainable, often makes it difficult and confusing for the novice to make a proper selection. Generally speaking short, stubby, light weight bullets will only perform well with reduced charges and at short ranges, while bullets approximating the length and weight of standard factory bullets of their caliber will usually perform well with reduced and full 314
charges at least up to the longest conventional revolver range of 50 yards. I say usually, because there are a few bullets for which moulds are available that have no rhyme or reason for their design. Fortunately however, the majority are bullets that were patterned after older ones which have preceded them and even though the designers may have known little or nothing of bullet design, the pattern they have attempted to improve upon has been a guiding light. As a matter of fact, revolver ranges are so short that almost any slug approximating the conventional limits of weight and shape will shoot pretty well regardless of which end is loaded into the cartridge case first, so the selection of a revolver bullet is not particularly difficult. A good rule of thumb for the beginner is to use the so-called standard bullets as recommended for any particular caliber by the manufacturers of bullet moulds. Of course, if one is associated with other revolver shooters who reload their own ammunition, their experience is always a helpful guide, but in the absence of this, the standard bullets are the best bet to start out with. Later on, one can try something different.

Wad Cutter Bullets. This type of bullet mould has an appeal to the target shooter because of the clean hole it cuts in the target, but generally speaking sharp shoulder bullets are ballistical monstrosities. They are essentially cylindrical slugs with lubrication grooves in them, having a flat nose or at best a flat with a stubby projection in the center which serves no particular purpose. That good accuracy can be obtained with them is due principally to the short ranges at which they are fired, the air resistance on the flat nose hardly having time to make itself felt before the bullet reaches the target. Some of these bullets, however, have an elongated projection on the nose which does stick out far enough to break away through the atmosphere so that the bow wave created by the forward end of the bullet clears the sharp shoulder. Such bullets are much more stable in flight than those with flat or practic- 315
ally flat faces. The latter are usually unstable in flight and show some signs of tipping on the target, but this does not mean that they are inaccurate. While those with the longer projecting points are more stable and the best of the two for all around purposes, they are not *always* stable in flight. Either type when fired with reduced loads will tip or key hole in a strong, cross wind.

The stability of a bullet is dependent upon the speed of rotation and the speed of rotation depends upon the muzzle velocity. For simplicity let us suppose that the rifling in the barrel of a revolver has a pitch of one complete turn in 12". If a bullet is fired with a muzzle velocity of 500 feet per second it will rotate at the rate of 500 revolutions per second but if the same bullet is given a velocity of 1,000 feet per second it will rotate twice as rapidly. The rotational velocity of a bullet is the muzzle velocity in feet per second multiplied by 12 and divided by the number of inches in which the rifling makes one complete turn.

In spite of its ballistic faults the sharp shoulder bullet is by no means to be condemned. Factory cartridges loaded with such bullets usually have charges of powder somewhat below the full service loads for the same caliber. These so called "mid range" loads, because of the lessened recoil, are excellent for target shooting and some of the ammunition manufacturers are producing loads of this type of such a high degree of accuracy that the reloader will be put to special pains to duplicate them.

Hollow Base Bullets. The early breech loading revolvers had chambers that were straight cylinders from one end to the other. They used cartridges loaded with bullets the same diameter as the outside of the cartridge case, except for a heel of smaller diameter which fitted the inside of the cartridge case. The bullets were lubricated on the outside by dipping them into melted lubricant after the cartridges were loaded and were crimped in place by a crimp which was rolled in. Such cartridges were only loaded with black
316 powder and they were for the most part only fairly accurate. The small diameter heel would upset irregularly on firing, creating the equivalent of an imperfect or lopsided base. Incidentally, cartridge cases for outside lubricated cartridges are no longer manufactured and in reloading such ammunition there is no possible way of crimping the cases onto the heel of the bullet, consequently, the reloading of such revolver ammunition is impractical and unsatisfactory as the cartridge cases are bound to work off from the bullets under the influence of recoil.

The outside lubricated cartridges were messy and to overcome this, grooves were put into the bullets, which were made small enough in diameter so their cylindrical bodies would fit inside of the cases; the cases were then lengthened to cover these lubricating grooves. This made the bullets entirely too small to fit the rifling. These did not shoot with any accuracy at all. It was necessary to make the bullets of soft alloys and with deep concavities in the bases so that the bases would expand readily and take the rifling. These hollow bases were especially necessary with smokeless powder charges which did not cause as much upsettage of the bullet base as black powder.

Modern revolvers are chambered for these inside lubricated cartridges and furthermore the barrels are bored and rifled for the smaller sized bullets.

Hollow base bullets should never be used in a revolver with heavy charges as such charges will cause the bases to upset excessively between the cylinder and barrel, causing pressures to rise above the expected point. With the following exceptions, there is no object in using a bullet with a hollow base in a revolver if the diameter of the bullet is as great as the groove diameter of the barrel:

A hollow base lightens a bullet, so that by making a hollow base bullet the bearing surface can be lengthened without increasing the normal bullet weight.

Some sharp shoulder bullets are seated deep in the cases

to improve the performance of the powder charge. If these 317
bullets had flat bases the density of loading might be too high and the powder charge would have to be reduced. A hollow base makes it possible for the manufacturer to control the density of loading or the air space over the powder charge to suit the needs of any particular charge and lot of powder. These deep seated bullets, because of the longer jump before they strike the rifling, have more slippage but the longer bearing surface made possible by the hollow base helps to straighten them up and offsets any evil of the longer jump.

But hollow base bullets are hard to cast. Furthermore, to make the nice calculations necessary to control the volume of the cavity in the base in order to get the best results with any particular kind and lot of powder requires facilities beyond the reach of the reloader. Good results may be obtained by loading in this way, but better average results will be had if flat base bullets are used and are seated to a normal depth.

Primers and Priming.

Revolver primers are of two sizes: a large size having a diameter of .210 inch and a small size measuring .175 inch. The caliber .45 Automatic Pistol cartridge, which can be used in the Model 1917 revolver, is loaded commercially with the large revolver size; but most of the ammunition of this caliber *made for or by the U. S. Government*, takes a special size primer with a diameter of .204 inch, which must be obtained through the Director of Civilian Marksmanship.

While all manufacturers make primers of the same diameters, they are by no means the same otherwise. Some are higher than others, and the primer pockets in the cases are correspondingly deeper; but these differences in dimensions are usually so small that any make of primer can be said to be interchangeable in all makes of cartridge cases taking that size.

Every ammunition manufacturer has his own priming formulas and there are no two of these exactly alike. This means that the flash and heat developed by different makes 318
of primers is not the same. When ammunition is made, the flash hole or vent in the bottom of the primer pocket is made of a size suitable to give proper ignition with the *particular primer* with which that lot of ammunition is loaded. Let us assume a situation requiring an exceptionally large vent. If these cases are reloaded with another make of primer, intended for use in cases with small vents, a higher order of ignition will be obtained and the chamber pressure will be increased. The increase is not apt to be dangerous with any normal load, but it would be with a maximum load. Now, if we reverse the process, and load the weaker primers into cases with small vents the ignition will most certainly be insufficient, even though the ammunition *appears* to shoot alright. Needless to say, a mixture of ammunition loaded as above could hardly be expected to give the best results.

It is advisable, for the above reasons, to use primers of the same make as your cartridge cases, not only to insure a proper fit and depth of seating, but to insure proper ignition of the powder charges.

Before seating fresh primers the primer pockets should be inspected for excessive fouling or corrosion and for breaks in the "webs" or bottoms of the pockets. Of the three, fouling is the least important and will seldom be present in a quantity that will be injurious to good ignition. Enough fouling may, however, be imprisoned under the anvil to cushion the blow of the firing pin.

Corrosion is a worse evil. Primers will not seat smoothly in corroded pockets, and if the primer cups are thin and soft (as they are in at least one make of primer) the primer may be deformed and the anvil cocked, i. e., both sides of the anvil will not bear evenly on the bottom of the primer pocket.

Cracked and broken webs are the worst offenders. Fortunately, they are not of very frequent occurrence except in the larger revolver calibers, when they have been fired with
319 mercuric primers. The effect that mercuric primers have on brass is described elsewhere in this book. In this connection it is well to remember that factory ammunition is not loaded with the same primers as those available for reloading purposes. Much factory ammunition is still loaded with mercuric primers, so it is well to inspect the webs before repriming the cases. If the web is broken away completely the blow of the firing pin may drive the primer through the bottom of the primer pocket without firing it at all or, at best, give a low order of ignition. If the web is cracked a greater amount of flash than normal will reach the powder and increase its rate of burning and pressure.

There is another objection to cracked webs. It is estimated that the pressure built up in the *primer pockets* of high power rifle ammunition does not exceed 5,000 pounds per square inch, even though the chamber pressure may be as high as 50,000 pounds per square inch. The reason for the low primer pressure is the small vent through which the powder gases must pass. In revolver cartridges, the primer pressure is less than 5,000 pounds, but if the webs are broken the powder gases can easily pass into the primer pockets and drive the primers violently back against the recoil plate setting this part back and necessitating sending the revolver to the factory for adjustment.

Primer Seating. Everything that has been said relative to seating primers in rifle cartridges applies equally well to revolver cartridges, although minor faults in primers and primer seating will not make themselves as apparent in revolver ammunition as in rifle ammunition because of the greater intrinsic accuracy in rifles, the longer ranges at which they are used, and the smaller groups that are expected from them. This, however, is no reason for being careless in the seating of primers for the hand gun. Special care must be taken, however, that primers do not project in the slightest degree above the heads of revolver cartridge cases. The recoil of the gun throws the unfired cartridge back violently and as some of our modern prim-
320 ers are more sensitive to shock than the older varieties, a high primer might be discharged on impact with the frame of the gun, and the chamber not being aligned with the barrel, the bullet might strain the gun in some way, if its departure were obstructed by the forward part of the frame.

Powders and Powder Charges.

The powders best suited for use in revolvers are Hercules Bullseye and Unique and DuPont No. 5, No. 6, and No. 80 Unique and No. 80 are primarily rifle powders but give excellent results in revolvers. Unique is especially desirable for higher than normal velocities without exceeding recommended pressure limits. No. 80 is intended to burn at higher pressures than are ordinarily developed in revolvers and consequently does not burn completely in revolver loads, but this is of minor importance. The important thing is to have the same amount of powder burn each time and No. 80 does this, consequently it gives good accuracy. The other powders are made especially for pistols and revolvers and will be found better suited for general use in such cartridges. They will ignite more easily with revolver primers and burn better than the rifle powders. The choice between them is largely one of preference.

Any of these powders can be measured with satisfactory accuracy with the Ideal, Bond, or Belding and Mull mechanical powder measures. For all normal charges these measures can be set according to the tables furnished with them without the aid of a scale or balance. Setting the measures by the tables may give a charge slightly different from the charge desired, but it will be safe and close enough for all practical purposes. If a charge of an exact given weight is desired, the measure should be set with the aid of a scale or balance as previouly described.

Dip measures or scoops are not generally recommended for use with dense smokeless powders. They must be used with great care in order to get uniform charges, and if one has scoops for several different powders there is always a chance that the wrong scoop may be used with disastrous results. However, the scoop or dip measure can be used 321
with reasonable satisfaction if the precaution is taken to make it so it cannot possibly hold an over charge. Belding and Mull will make up scoops for smokeless powder charges to special order or one can make his own from a black powder scoop or an empty case filed down to hold the proper charge.

A five-cent aluminum funnel forced into the end of a short drop tube of an Ideal Powder Measure makes a very convenient arrangement for pouring the charges into the cases. Need we caution against pouring two charges into one case?

A loading block is a practical necessity to the reloader. They can be purchased or made by boring a series of holes of the proper depth into a piece of board. Bullets should never be seated in cases without first inspecting the powder charges. If the charged cases are put in a loading block, the block can be tipped towards a good light and the height of the charges observed. An overcharged case will be apparent at once. In the manufacture of ammunition electrical or mechanical gauges or visual inspection is always used to verify powder charges before the bullets are seated and the hand loader cannot afford to be less careful.

Chapter Fourteen 322

LOADING FOR AUTOMATIC ARMS.

When loading ammunition for hand operated rifles, single shot pistols or revolvers, the prime limiting factor is the chamber pressure. If the cartridges for any of these arms do not develop pressures in excess of those dictated by experience and good judgment and the ammunition is accurate, it can be considered as perfectly satisfactory.

This is not always true of ammunition intended for use in the so-called "automatic" or self-loading arms for, although the pressures must be kept within safe limits, there are other factors which inject themselves into the situation. Automatic rifles and pistols depend for their functioning upon the use of a certain amount of the energy of the cartridge fired in them. As this energy is exerted to the rear, it is necessary to pay particular attention to it when loading the ammunition. In the hand operated arms, we think only of the effects produced upon the bullet and the movement of the bullet in a forward direction, but the peculiarities of the automatics make it necessary to "think in two directions."

It is possible to reload ammunition with cast bullets that will cause severe battering of the moving parts of an automatic arm, even though the pressures developed are well within the recommended limits for the arm. The points to be observed in loading ammunition for the automatics depend upon the mechanical principle of operation
323 of the particular type of automatic arm that the ammunition is being loaded for. All self-loading arms do not work on the same principle and to understand the points to guard against in loading ammunition for any of them, it is first necessary to know in a general way how these arms operate. They are all the same in that firing a cartridge causes the breech to open, the cartridge case to be extracted and ejected, the arm cocked, a new cartridge to be pushed into the chamber and the arm left ready to be fired again by another pressure of the trigger—but the method by which these several things are accomplished differs.

The three general classifications of automatic or self-loading arms as they should more properly be called, are: blow-back, recoil operated, and gas operated. A fourth classification might well be placed between the first two and called "delayed blow-back."

Blow-Back Actions. Blow-back actions are those in which the barrel and breech block are never locked together, the breech block remaining in the closed position only by virtue of the tension of the recoil spring. When a cartridge is fired in this type of action, the cartridge case is driven to the rear by the gas pressure at the same time that the bullet is driven forward. This two-direction thrust is, of course, common to all types of arms but in the blow-back action the head of the cartridge case does not meet the resisting wall of a locked or solid breech—it pushes the movable breech block to the rear. Because of the weight and inertia of the breech block, to say nothing of the resistance of the recoil spring, friction and the effort to cock the piece, the rearward movement of the breech block is very much slower than the movement of the bullet. Consequently, in this type of mechanism the breech block only moves a small fraction of an inch to the rear and is not open far enough to permit the escape of gas by the time the bullet leaves the muzzle. The

continued movement of the recoiling parts to the rear is due to the momentum given them during the short period 324 of time the bullet is moving through the barrel. This momentum normally carries the breech block (or slide, in the case of an automatic pistol) to its rearmost position.

The thrust imparted to the breech block depends upon the same factors which govern the velocity of the bullet; namely, the chamber pressure and the manner in which the pressure is developed plus the area on which the pressure works, which can be translated into the area of the head of the cartridge case. For these reasons, the blow-back type of action is limited to the use of low power cartridges and, in the case of pistols, to cartridges of small head diameter. The rifles employing this principle can use larger and more powerful cartridges because of the heavier breech blocks and stiffer springs that can be used in them, but even the rifle cartridges have decided limitations.

Blow-back actions are not adapted to the use of cartridges developing high velocities or high chamber pressures and in reloading ammunition for such arms the loads should never exceed the limits prescribed for standard charges.

All small frame automatic pistols that I know of, whether of domestic or foreign manufacture, up to .380 caliber (9 m/m short) operate on the blow-back principle. This is certainly true of the Colt automatic pistols in calibers .25, .32 and .380 as well as the .35 and .32 S. & W. automatics. Other pistols of this type in more or less common use in the United States are the Ortgies and small models of Mauser automatics, to say nothing of the conglomeration of cheap mail order pistols.

Among rifles, we find only three American automatics operating on the blow-back principle. These are the Model '05 Winchester caliber .32 and .35 self-loading rifles, the Model '07 Winchester caliber .351 self-loading rifle and the Model 10 Winchester caliber .401 self-loading rifle. Being rifles, and allowing a greater amount of weight in the mechanism than in automatic pistols, more powerful cartridges can be used than in the blow-back pistol actions, 325 but even so the cartridges for these automatic rifles are little more than glorified pistol cartridges.

Any attempt to overload ammunition for any of the arms mentioned, even though the pressures are well below a dangerous point, can only result in injury to the arm. The velocity of the recoiling parts will be increased, this sooner or later will cause damage of one kind or another to the mechanism. The point to remember in reloading ammunition for these arms is that the normal chamber pressure is the limiting factor. Cast bullets, because of their soft nature, will start on their way and accelerate more quickly in a barrel than a jacketed bullet of equal weight and bearing surface. Consequently, it is frequently possible in automatic arms to get higher muzzle velocities with cast bullets than can be obtained with jacketed bullets and furthermore, this can be done without exceeding normal pressures.

Delayed Blow-Back. This is a cross between the blow-back and the recoil operated type of action. In it, the breech block is never really locked to the barrel but there is some mechanical resistance offered to the breech block to delay its initial movement so it will not recoil and open as easily as a straight blow-back action. The only arms that the handloader is likely to encounter which operate on the delayed blow-back principle are the Savage automatic pistols. Practically, the "delay" in operation of these pistols is insignificant, if, indeed, there is any delay at all. Ammunition for them should be reloaded the same as for blow-back pistols of similar caliber.

Recoil Operated Arms. In the recoil operated type of automatic pistol or rifle we have a mechanism that is entirely different in principle from the blow-back and one which requires different treatment in loading the ammunition for it. In this type, the breech block and the barrel are securely locked together at the time the cartridge is fired and normally remain locked until the bullet is out of the 326 barrel. When the arm is fired the barrel and the breech, in a locked position, recoil to the rear together and the energy of recoil is used to unlock the breech from the barrel, permitting the breech block to continue its rearward movement alone, extracting the cartridge case from the chamber and performing its other normal functions. In this type of action the barrel and breech block can move to the rear independently of the rest of the arm.

Among the automatic pistols operating on the recoil principle, we find all the .38 caliber Colts as well as the .45 Government model, the Luger and the military Mausers. There is only one model of American auto rifle using center-fire ammunition in this category; namely, the Model 8 Remington autoloading rifle, which is made for the calibers .25, .30, .32 and .35 Remington cartridges.

As these recoil operated arms have their breech blocks or slides locked to the barrel it is possible to use more powerful cartridges in them than can be used in a blow-back arm, although even these locked actions have their limitations. During the interval that the two are locked together they recoil in much the same way that a hand-operated rifle recoils when fired. The energy that is imparted to them is influenced by the weight of the bullet, the barrel time and the rate that the bullet accelerates in the barrel. Lead bullets impress themselves into the rifling more easily than jacketed bullets and consequently do not require as high a chamber pressure to develop a given velocity as a metal jacketed bullet. If lead bullets are loaded up to the limit of the permissible chamber pressure the acceleration of the bullet will be greater than a metal jacketed bullet and consequently the velocity of the recoiling parts will be greater. This will lead to more or less upsetting and deformation of the parts of the gun that arrests the rearward motion of the breech block. Many of the loads published in tables of charges do not take this factor into consideration, and it is a good plan for the reloader who wishes to keep his self-loading rifle or pistol in 327 good condition to experiment with reduced charges and find out just how little powder he can use with any given bullet to barely cause the arm to function. With this minimum as a base he can establish his charge somewhere between this point and any recommended load, but should never exceed any recommended full charge whether using

lead or metal jacketed bullets. It is also a good plan with any automatic arm to examine the recoiling parts carefully from time to time for any evidence of battering or upsetting, and the first sign of such a condition should be heeded and the load reduced slightly.

The positive functioning of self-loading arms requires that the cartridges enter the chamber freely. Therefore the chambers are apt to be a little large. This condition may result in excessive expansion of the cases and tearing of the brass in the solid head of the case. This condition is described in detail under the subject of Resizing Cartridge Cases, but in order to be sure of proper functioning it is almost always necessary to resize the cases to their original dimensions. It depends upon the particular type of arm and the nature of the loads used. For example, the Luger, Mauser, .32 Auto and .380 Auto cartridge can sometimes be reloaded several times without resizing the cases. On the other hand, the .45 Auto and most of the automatic rifles are apt to malfunction if the cases are not resized full length every time they are reloaded. As previously mentioned, the resizing of cases that have cracks or tears in the solid heads is not desirable, but rarely causes any trouble when moderate loads are used except in the Cal. .45 Automatic Pistol. This caliber, while by no means dangerous to reload, is nevertheless worthy of special attention.

Reloading the .45 Automatic

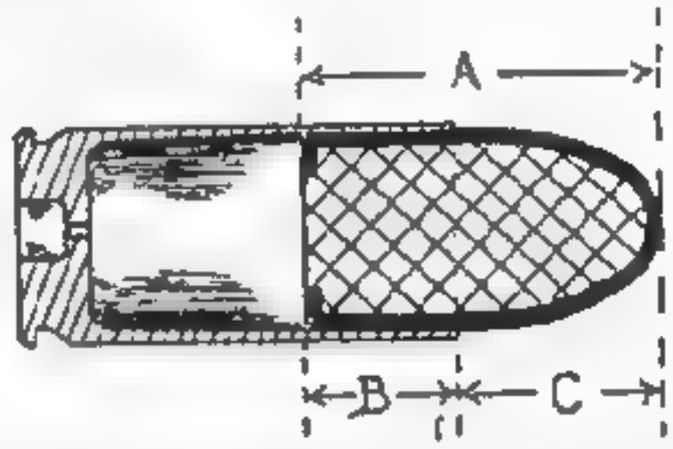
This cartridge because of loose chambering and poor support at the lower part of the chamber where the metal is beveled to permit easy feeding of the cartridges from the magazine, bulges considerably at the head when fired. This causes cracks to occur in the solid head. The case is so large in diameter and so short that it is easy to inspect them for 328 this defect by merely looking into them in a good light. If they are cracked all the way around the inside of the head it is best to discard them.

The photograph shown on Plate XIX is of a section of a Cal. .45 Automatic Pistol barrel with a cartridge in the chamber. It will be seen that the cartridge is positioned in the chamber by the square, uncrimped edge coming in contact with the square shoulder of the chamber. This contact supports the cartridge against the blow of the firing pin. The head of the case is flush with the barrel extension. If the cartridge were crimped, it would go deeper into the chamber, the head space would be excessive, and a too light blow from the firing pin would cause ignition troubles.

It can be seen that the under side of the case receives very little support and that the looseness of the chambering leaves a considerable space over the top of the cartridge. This is what causes the case to expand considerably and tear the brass apart slightly inside of the solid head.

Unfortunately, all cases for the .45 auto are not as long as they should be and before reloading it is well to measure them. They should be from .892" to .898" long. A simple way to gauge them is to remove the barrel from the pistol and use it as a gauge. Resize the cases and try them in the chamber. The heads should be just flush with, or very slightly below, the projection at the rear end of the barrel. If they project a few thousandths of an inch above this protection it will usually do no harm provided the slide can close and the disconnector can enter the depression in the under side of the slide. The thing to watch out for is *short* cases, and if you find any below the minimum dimension given above or any that seat appreciably *below* the end of the barrel it is best not to reload them.

One is limited in the variations that are permissible either in the weights or shapes of bullets that may be used in automatic pistols as well as in the dimensions of the finished cartridge. Sharp shoulder bullets will not feed 329 properly, but can be used if the pistol is used as a single shot weapon. The standard weight of bullet for the .45 Auto is 230 grains. If a lighter bullet is used, the gun will shoot lower than normal and a heavier bullet will make it shoot higher, *regardless of the powder charge used*. One is also limited as to the depth to which bullets may be seated. The diagram on this page has three dimensions marked A, B, and C. If the dimension A is moved back,



the length of the cartridge will be decreased. This will not usually effect the functioning, but it will increase the density of loading (decrease the air space), which will raise the pressure. If A is moved forward, the over-all length of the cartridge will be too great for it to enter the magazine.

If bullets longer than normal are used and the cartridge loaded to its proper length, the dimension B and the density of loading will be increased and as this would imply a heavier bullet than normal, the pressure and the recoil of the slide will be increased without any benefit in the external ballistics of the load.

The dimension C must be kept reasonably close to the normal for proper functioning.

A word about jamming. Jams are usually the fault of the magazine. If the lips become spread too much the head of the cartridge will jump out too quickly. If they are bent in too much they will not let the head come up quickly enough and the slide will ride over the head instead of pushing it into the chamber. In either case, the slide may 330 catch the cartridge in an abnormal position and cause a jam. This assumes that a bullet of the proper shape is used and that the projection of the bullet (dimension C on the sketch) is correct. The nose of the bullet should be rounded and more or less the same shape as the factory bullet.

Cast bullets for automatic arms may be any temper that one wishes to use but hard bullets resist deformation in handling and loading and in arms where the bullet rubs on the chamber wall while passing from the magazine into the chamber hard bullets will have less "drag" than soft ones. This doesn't make any noticeable difference in functioning except when loads are reduced to an extent where

they will barely function the mechanism.

Gas Operated Arms. This type of automatic is of little interest to the handloader for, in order to utilize the gasses of combustion to operate the mechanism the weight of the arm is usually increased to a point that renders it unsuited to sporting uses. With one exception, this principle is found only in military automatics or machine rifles and machine guns. The one exception is the Standard automatic rifle, now obsolete, which was chambered for the Remington automatic rifle cartridges. This arm was not a bad one and was unique in that it could be functioned either as an automatic or as a hand operated, slide action rifle. There are still quite a number of these Standard rifles in use and they are much liked and sought after by those who are familiar with them. If used as hand operated arms, the reloading of ammunition for them is subject to the same loading principles as that for any other manually operated rifle of the same caliber. As an automatic arm, little departure can be made from those loads which duplicate or approximately duplicate, the factory standard cartridge.

In gas operated arms there is a hole or port in the barrel at some distance back from the muzzle or some device at the muzzle that permits some of the gas behind the bullet to be utilized in operating the arm. As the bullet passes 331
the port, some of the gas escapes through the port and acts on a piston or other movable member, the motion of which unlocks the breech block or bolt and imparts the necessary movement to it. As these arms are designed for use with military or commercial ammunition developing relatively high pressures, they will not function with reduced loads or with quick burning powders. The pressure remaining behind the bullet must be high enough to function the arm when the bullet passes the point in the barrel where the gas escapes to act on the operating mechanism.

Chapter Fifteen 332

LOADING FOR EXTREME ACCURACY.

"Loading for extreme accuracy" has been a stock phrase in most of the handbooks on reloading. Personally, I don't know how to define the phrase "extreme accuracy" as related to handloading. It can't be reduced to arbitrary group sizes and in some arms the accuracy may only be mediocre, in spite of any extraordinary pains that may be taken in assembling the ammunition. The best interpretation I can place on this oft repeated phrase is, *loading ammunition so as to develop the very best capabilities of a particular arm for a particular range.* The subject is one that is confined primarily to the loading of rifle ammunition because the pistol and revolver are somewhat limited in their accuracy by design, short sight radius, and certain human limitations in firing them. On the other hand, the rifle can be readily controlled and fired by the shooter to an extent that will reflect almost the limit of its intrinsic accuracy on the target.

To get the best accuracy out of any rifle requires a careful study of the arm as well as care in loading the ammunition. As far as the latter is concerned, the difference between the ordinary loading of ammunition and loading for extreme accuracy is largely one of paying careful attention to small details, any one of which may be insignificant in itself but, the total of which may make accumulative error sufficient to cause some small enlargement of the groups.

333 In the past few years, several arms and cartridges have made their appearance on the market that developed a high degree of accuracy, higher than was commonly encountered in previous commercial arms and ammunition. There is nothing magic about these arms and their ammunition. Taking the .257 Roberts as an example, it will be found on analysis that the dimensions of the chambers in these arms bear a closer relation to the dimensions of the cartridges made for them than was formerly common in commercial arms. This is true of the .22 Hornet and .220 Swift as well and we find close throating in addition to close chambering, so that the jump of the bullet before it strikes the rifling is reduced. The difference between the dimensions of a maximum cartridge and a minimum chamber in these arms is so close as to approximate the so-called "tight chamber." This means that when the cartridge case expands at the neck, as the gasses develop, the expansion while sufficient to release the bullet and permit the escape of some gas past it to relieve the pressure, nevertheless is so slight that there is little opportunity for the bullet to go anywhere except straight into the barrel. Chamber the 7 m/m, .30'06, .25/20 and a hat full of other calibers with an equal degree of precision and you will get extreme accuracy from them also. About the only thing that can be considered as an advance in these new calibers is that the arms and ammunition manufacturers have been able to increase the standard of mechanical accuracy of their products in commercial production.

Another factor which has had a very material effect upon the subject of extreme accuracy is the remaining velocity of the bullet at any range, about which more will be said later. The model 70 Winchester rifle has recently been made available chambered for the .300 Magnum cartridge and this rifle, equipped with a heavy barrel, has already demonstrated a superior degree of long range accuracy. Is this because there is something magic about the .300 Magnum cartridge? No. Is it because this particular .30
334 caliber barrel is made more accurately than other .30 caliber barrels? No. It is due to the combination of a good barrel, properly mounted and stocked, and equipped with a good firing mechanism. The barrel is chambered and throated and the ammunition made so that the two fit much more closely than would be permissible, for example, in a military rifle—plus another important factor. Under the subject of exterior ballistics, much has been made of the fact that a high velocity bullet is unstable in the beginning of its flight but finally, according to the bullet design and its speed of rotation, it settles down and flys steadily over a considerable part of its trajectory. As it loses more and more of its velocity, yaw or wobble sets in. For the best of long range accuracy it is imperative that the bullet be driven with a high enough muzzle velocity so that yaw will not have set in by the time the bullet reaches the

target. With the .30'06 cartridge, it is necessary to load the ammunition right up to the hilt in order to get the best long range accuracy, but by the time the bullet has gotten out to 1,000 yards the velocity has dropped down to around 1500 feet per second, which isn't so hot. The larger capacity of the .300 Magnum case permits the use of different powders and makes possible a higher muzzle velocity and as a consequence a higher remaining velocity at 1,000 yards, with a little better degree of accuracy at the longer range. It takes pains, study and workmanship to bring commercial arms and ammunition to such a degree of perfection and there is a lot more to it than has been mentioned here, but the point I wish to bring out is that there is a very definite ballistic reason for fine accuracy and the principles behind it are not limited to any particular cartridge or calibers of weapons.

Ballistic Fundamentals That Effect Accuracy.

We can't reduce the chamber tolerances in the arms that we already have, in order to make them more accurate than they are, nor can we boost muzzle velocities beyond a point that is consistent with safe pressures. On the other hand, we can oftentimes improve on the normal 335
accuracy of these arms by working on the ammunition and by giving due consideration to the ballistic fundamentals that effect accuracy.

Ballistic Coefficient. In order to explain these fundamentals, it is necessary to go a little bit further into the subject of ballistics and consider the factors affecting the performance of a bullet in flight. Bullets of different shapes, weights and calibers do not perform the same when passing through the atmosphere, some being retarded more than others. In exterior ballistic calculations, a numerical value must be assigned to each bullet, which represents its atmosphere penetrating abilities. This factor is known as the ballistic coefficient and is obtained by dividing the mass of the bullet, or its weight in pounds, by the square of its diameter in inches which gives the sectional density of the bullet, and then dividing the sectional density by a factor of form called the coefficient of form.

The calculation of the coefficient of form is the most difficult factor in arriving at the ballistic coefficient. It may be done approximately by comparing the shape of one bullet with another of a known form factor, but this is unreliable. For accurate results, the bullet must be fired over different ranges and the remaining velocity obtained empirically at different distances from the gun. By working back through a process of elimination, a fairly accurate value for the form factor can be arrived at.

Scribing arcs of circles for comparison with the profile of the ogive, or tapered portion of the bullet, is unsatisfactory for while the word "ogive" is used loosely in referring to the curved or tapered forward portion of a bullet, nevertheless, there are very few bullets whose noses are truly ogival, the majority are parabolas or tapers, so there is no satisfactory basis for comparison in this way. Furthermore, when a bullet is truly ogival, the shortness of the arc forming the side of its profile makes such a comparison difficult and then the manufacturing tolerances 336
or errors in manufacture can give an error of as much as two calibers in the radius of the arc. However, we are not interested here in the calculation of ballistic coefficients of bullets, but rather only in the fact that there is such a thing and that it has a material effect upon the performance of the bullet in flight.

The atmosphere itself is a troublesome thing in ballistic computations, because no satisfactory fixed means has yet been arrived at for computing air resistance at all barometric pressures and at all velocities. Regardless of the bullet's ballistic coefficient, its performance changes with changes in atmospheric density and with the velocity at which it is travelling at any time. It will also be noted that the ballistic coefficient varies with any change in the weight of the bullet, in its diameter, or in its shape. For example, if two bullets were of exactly the same shape and dimensions but one was a cast bullet and the other a jacketed bullet, there would be a difference in their weights and a consequent difference in their ballistic coefficients. These facts are mentioned as a further amplification of a preceding statement that mathematical ballistic computations are of little or no value to the handloader.

Initial Yaw. When driven from the muzzle of a gun the bullet is unstable during the early portion of its flight, in which performance it is aptly likened to a spinning top. The conventional top, when first spun and when rotated at its most rapid velocity, wobbles about on its peg but finally attains a speed where it settles down and spins quite steadily until its rotation drops off to a point where instability sets in again. The performance of a bullet is quite similar and the bullet likewise settles down to a steady flight until its velocity drops off to a point where yaw sets in again. The causes of initial yaw and yaw are not the same.

337 In loading ammunition for extreme accuracy, the abnormal conditions which promote initial yaw are of more interest to us than the yaw that takes place during the bullet's so-called terminal velocity, which is reached somewhere in the descending branch of its trajectory. The factors causing initial yaw may be divided into two parts. First: The factors of rotation and atmospheric penetration, which are fundamental physical causes and which reduce as the forward velocity and rotation of the bullet changes until finally the yaw practically disappears. The reloader can only influence these causes within the limits that he can control the muzzle velocity of the bullet.

The second part involves those factors within the bullet itself; these involve manufacturing errors in the bullet and deformations that may take place while it is passing through the bore. These variations, or defects, or the departures from what might be termed a hypothetically perfect bullet, bring about a type of yaw or instability which does not correct itself during the bullet's flight and may increase to a point where the bullet's accuracy is seriously impaired. For example, the ballistic coefficient of a bullet becomes useless unless the bullet is flying truly on its long axis. If there is wobbling or oscillating in flight, the air resistance is increased and the bullet is abnormally retarded in proportion to the increased air resistance. Some of the

conditions affecting that part of the initial yaw pertaining to errors in the bullet itself can be eliminated, or at least greatly reduced by a careful selection of bullets and intelligent loading.

Muzzle Loading of Bullets. Many of the old black powder rifles had rather deep grooves in the barrel and a bullet in passing through them had a considerable amount of lead displaced by the grooves. This lead was forced back and frequently formed projecting fins on the bullet base. As these fins could not be depended upon to be uniform, the gas impinged on them differently as successive bullets left the muzzle of the arm, which increased the initial yaw and, in all probability, also caused some deflection of the axis of the bullet from the normal line of flight. To get around this, many of the older lead 338
bullets were made with a slight bevel on the base, which did give improved accuracy where the bevel was concentric with the bearing surface of the bullet.

The fins were entirely avoided by loading the bullets from the muzzle by the so-called Pope muzzle loading system. Heavy barrels for this purpose were made in the usual manner, after which several small holes were drilled around the muzzle and parallel to the bore, to the depth of a couple of inches. These holes were irregularly spaced and sometimes were of slightly different sizes. The end of the barrel was cut off above the point where the small holes ended, this piece being known as the "false muzzle." The ends of the false muzzle, as well as the muzzle of the barrel, were squared up so that the two fitted together perfectly, after which the rifling in the false muzzle matched exactly with the rifling in the barrel. The false muzzle was fitted with dowel pins and the rifling in the upper or forward part of it was carefully reamed out leaving it smooth and exactly the groove diameter of the barrel. A short rod, recessed at one end to exactly fit the shape of the bullet nose and having a large knob or flattened palm rest on the other end formed part of the equipment and served as a bullet starter.

The method of using one of these arms was as follows: The powder charge was measured and poured down the barrel, if the arm was a true muzzle loader. If a breech loader, the cartridge case, charged with powder was usually placed in the chamber after the bullet had been seated. The dowel pins in the false muzzle were inserted in the holes in the muzzle and, being unevenly spaced, the false muzzle would only go on in one position, with the remaining rifling in it continuous with the rifling in the barrel. The bullet, cast or sized to *groove diameter* (those who have been bitten with the idea that cast bullets *must* be .003" larger than groove diameter take note) was inserted in the smooth bored part of the false muzzle and with the bullet starter was driven or forced into the barrel. 339
The remaining rifling in the false muzzle served to form the rifling impression in the surface of the bullet and as the displacement of the bullet metal incident to this was forward, there could be no fins or projections on the base of the bullet. Once impressed into the rifling of the barrel, the bullet was seated to the proper depth with a ramrod. It is sufficient to state that the accuracy of many old arms loaded in this way was superb.

The formation of fins on bullet bases is of minor importance in modern rifles because of the relatively shallow grooves. With jacketed bullets it is probably of no importance, because no matter how sharply the jacket material is turned over the bullet base its stiffness is such that there is always a slight radius around the bullet base.

Another cause of yaw is the lack of concentricity in bullets. In cast bullets this may be due to slight irregularities in the mould that are not entirely eliminated by sizing and then again it may be due to improper sizing. In jacketed bullets it is due to unavoidable manufacturing tolerances. I say unavoidable because a manufacturer cannot be changing the dies in his machines every time he makes a batful of bullets and the materials from which bullets are made are also a limiting factor on absolute perfection. Most bullet jackets are made of gilding metal or a similar material in order to avoid the metal fouling that results from the use of cupro-nickel jacketed bullets when driven at high velocities. Gilding metal is a softer and more ductile alloy than cupro-nickel. It is easier to fabricate accurately but is more difficult to bring to a proper degree of hardness by cold work. From the standpoint of hardness or toughness cupro-nickel is superior, but gilding metal is satisfactory. However, in commercial production the points of jacketed bullets may be very slightly eccentric with relation to the axis of the body of the bullet and this condition when slight, as it usually is
340 when it occurs at all, is very difficult to detect. Spinning bullets is an unreliable method because of the errors that exist in the spinning devices themselves, although if the eccentricity of the bullet points is great enough it can be detected by spinning. Eccentricity of the point also causes irregularity in the ogive.

Bullets are not infrequently slightly out of round but this, as far as the body of the bullet is concerned, is not of serious consequence unless the condition is bad. The bullet in being forced through the rifling will in all probability be trued up, but due to the elasticity of the jacket material may spring back slightly after it leaves the muzzle. Some reloaders have claimed that out of round bullets will definitely not shoot into the same group as those which are round, when fired in exceptionally accurate arms. While not disputing such a statement, I can state definitely that I have fired .30 caliber flat base bullets that were as much as .0015" out of round from a Mann barrel at 600 yards and obtained exceptionally good accuracy with them. This is no defense of bullets that are out of round; in loading for extreme accuracy bullets should be selected that are as near perfect in all respects as possible.

If the body of a jacketed bullet is out of round, in all probability the ogive is also, although this is not necessarily true. In any event, from the standpoint of yaw, eccentricity in the ogive is of more importance than it is in the body of the bullet.

The curvature of the ogives of a lot of jacketed bullets will show some differences. This difference in curvature

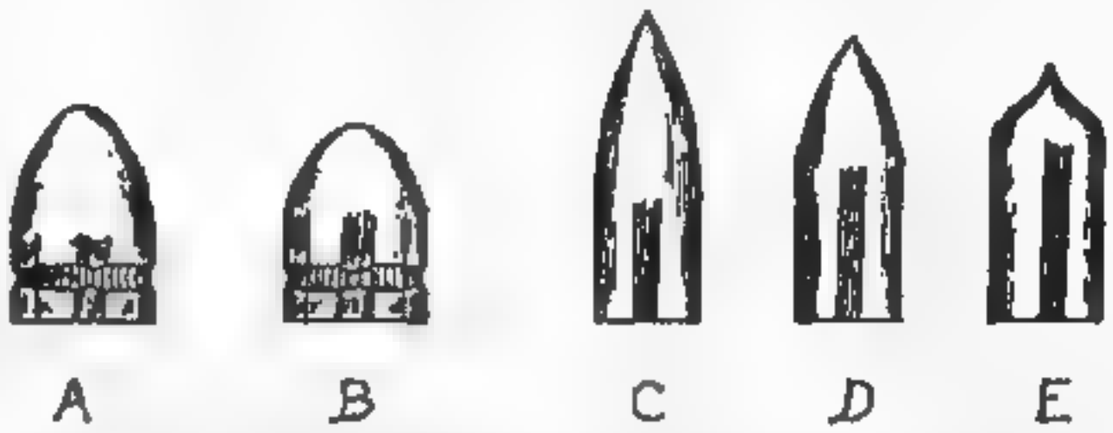
will not affect the yaw to any appreciable extent but it does affect the ballistic coefficient and will have some affect on accuracy, especially at the longer ranges. Variations in the curvature of ogives is difficult to detect and requires the use of accurately made profile gauges. The manufacture and verification of such gauges is a difficult and expensive proposition, outside of tool rooms especially equipped for the purpose, and the reloader had best forget 341
this unless he himself happens to be a tool maker. In any event, the variations in the ogives of jacketed bullets will not have much effect on even extreme accuracy within the ranges that reloaders ordinarily use their ammunition.

Another source of yaw is imperfect balance in the bullet. Even though a bullet may be of perfect form, its center of gravity may not coincide with the center of form. Variations in the wall thickness of the jackets as well as in the alloy of the core or, in the case of cast bullets, in the mixture of the elements in the alloy, may bring this condition about. When the bullet is passing through the barrel it is rotating around its center of form, but when flying freely through the air it rotates around its center of gravity and if the two are not coincident there will be more or less oscillation of the bullet from this cause. There is no means of inspection whereby such a condition can be detected and while the two centers probably do not coincide exactly except by chance, the chances of their difference being sufficient to cause material errors in accuracy are few.

I presume that if a person who had never seen a bullet read these remarks, he would imagine that a bullet was a sort of misshapen metal affair and that the chances of seeing two that looked alike would be remote, because the average mind is not accustomed to thinking in terms of the small variations that are involved. The accuracy and uniformity of bullets, whether jacketed or cast, is noteworthy; properly used they will give excellent accuracy without any special inspection or consideration by the reloader. This entire chapter is written for those who are of an experimental turn of mind and are continually seeking the elusive group where all the bullets go through the same hole; or for those who seem to get a great deal of their enjoyment out of the mental anguish which they go through in loading their ammunition. I, therefore, pause to remind the reader that the conditions mentioned, while real, are in many instances limited in their importance. They may all 342
occur at the same time without seriously impairing accuracy, as one condition can easily offset another, but if they are accumulative and in the wrong direction, the effect on accuracy will be appreciable.

Upsettage and Deformation. To get back on the track again; when a flat base bullet is fired it suffers a considerable upsettage at the base and in the average chamber may tip very slightly in one direction or another during the time that its inertia is being overcome and it slaps up against the rifling. This shock, coupled with the severe pressure exerted behind it, can easily cause slight deformation in a perfect bullet and as this is a normal and expected condition there is a limit to the beneficial results that can be realized by the careful selection of bullets.

In addition to upsetting, there is another factor that causes a change in bullet form while passing through the bore. This is known as "slugging" and is caused by driving



A—Revolver bullet, normal. B—Same bullet fired with heavy charge & short barrel, showing upsetting or slugging. Note that bullet is shorter and bearing surface is longer, as shown by greater length of rifling marks. C—30-06 bullet, normal. D—Same, fired with excess charge, showing slugging. E—A bullet recovered from a gun burst by the firing of a terrifically excessive charge of powder which burst the receiver. This bullet did not leave the barrel, but was upset about as shown. Charge was 45 grains of Bullseye in 30-06 case.

bullets with more force than their structure will permit. If a bullet has a thin jacket, the effect of the gas on the base may very easily drive the core into the bullet so as to cause its forward part to bulge more or less, thus changing its
343 shape. If the jacket is too weak, the core may actually be blown through it; while this is a rare occurrence with ammunition that is correctly loaded, it is by no means unknown. Therefore, the rigidity of the bullet must be taken into consideration when loading it, if the best of accuracy is to be obtained. If the deformation due to slugging is appreciable, it will effect both the ballistic coefficient and the yaw, because the deformation is not apt to be symmetrical. It is quite probable that a certain amount of slugging takes place in jacketed bullets in normal high power cartridges, but because of the elasticity of the bullet the latter returns to, or approximately to, the original shape before leaving the muzzle.

When boat-tail bullets are fired they do not upset. The tapered base of the bullet causes the gas to act as a wedge and try to force its way in between the bearing surface of the bullet and the barrel. For this reason, boat-tail bullets must have exceptionally hard cores, as otherwise the gas at high pressure may force its way around the bullet, squeezing its diameter down and consequently ruining its accuracy. Boat-tail bullets are more difficult to manufacture accurately than flat base bullets and it is absolutely imperative that the boat tail be concentric with the point. Special precautions are taken in manufacture to achieve this but these efforts are not always attended with absolute success.

Yaw. With normal bullets the initial yaw dies down shortly after the bullet leaves the muzzle, but the exact distance from the muzzle of the gun that the bullet settles down to fly steadily, or "goes to sleep," depends upon the design of the bullet, its rate of rotation, the muzzle velocity and the degree of yaw that is present. If the yaw is excessive because of defects in the bullet itself, the velocity will fall off more rapidly than normal and as the condition from one shot to another will not be the same there will be a greater dispersion than normal. The further the bullet travels along its trajectory, the greater the effects of yaw or instability become. At shorter ranges they may scarcely be

noticeable, while at long ranges they will be marked. 344

It is believed by many authorities that yaw is the principal cause of dispersion, or the enlargement of groups. Because this instability of bullets or projectiles causes the axis to tip with relation to the normal line of the trajectory and causes not only a decrease in the range because of the abnormal air resistance, but lateral deflection as well, any irregularity in the ranging properties of successive shots can be translated to vertical dispersion on the conventional vertical target and on horizontal targets to an abnormal lengthening of the beaten zone.

It is believed that yaw in artillery projectiles is due entirely to the yaw of the projectile in the gun. An artillery projectile is different from a small arms bullet in nature and performance. These projectiles are made of iron and steel and depend upon their rotation by the rifling upon a "rotating band" of copper, which is shrunk or compressed into a groove at the rear end of the projectile. These rotating bands are sufficiently larger in diameter than the body of the projectile to take the rifling and are of a width that will offer sufficient resistance to the rifling to overcome the straight forward impulse of the projectile. Just in back of the ogive of the projectile there is a carefully machined area slightly larger than the projectile body and with a smooth finish, which is known as the "bourrelet." The diameter of the bourrelet cannot be larger than an easy sliding fit in the bore of the gun it is fired in, and any manufacturing tolerances must be on the minus side. Theoretically the projectile is guided at the rear by the rotating band and at the fore part by the bourrelet, but as there is always a slight amount of play between the bourrelet and the bore of the gun, the nose of the projectile may, and usually does, follow a set of lands and grooves down the bore with a slight spiral motion and actually yaw in the gun.

A small arms bullet on the other hand, is constructed of material sufficiently soft so that the entire cylindrical portion is impressed into the rifling and it does not have the same opportunity to yaw in the gun that an artillery projectile has unless, of course, it is sub-caliber, but small arms bullets can and do yaw in the barrel because of minor and unavoidable variations in their manufacture or because of deformations caused from the effects of firing. Some of these have previously been referred to.

Chamber and Bore Tolerance. With all the causes 345
of yaw that have been mentioned as pertaining to the bullet, there is also the nature of the arm to be considered. If the groove diameter of a barrel is normal and the bore is over-size, the condition actually may contribute to accuracy rather than detract from it, provided the depth of the grooves is sufficient to impart proper rotation to the bullet. However, a reverse condition of an abnormally large groove diameter, either with or without an undersize bore diameter may easily create yaw in the bullet while passing down the bore.

Then, there is always the throat or bullet seat in the barrel to be considered. This is perhaps the most important part of the barrel affecting accuracy and is represented by a bevel in the rifling immediately in front of the chamber proper. The form of the throat usually conforms to the shape of the bullet to be fired in it and this factor must be taken into consideration in designing bullets for any particular arm. It must also be taken into consideration when loading bullets that are of the same caliber but primarily intended for other cartridges than that for which a given arm is chambered.

In commercial and military arms the throat is so formed and located that the bullet normally jumps an appreciable distance before coming in contact with the throat and entering the rifling. The blow thus caused increases the barrel vibrations and may result in some minor deformation of the bullet. This tolerance is necessary in commercial arms to allow for normal variations in bullet shapes and to permit easy loading and functioning. In military arms it must be sufficient for these causes, plus dirt. It is doubtful 346
if the civilian rifleman who practically picks his own conditions for shooting and gives his pet rifle the most tender care has any idea of the severe conditions under which a military rifle must function in the field, but regardless of this, the fact remains that bullets jump forward in more or less of a straight line until they come in contact with the throat in the barrel.

It is not difficult to measure the amount that the bullet jumps in any rifle. To do this, insert a cartridge in the chamber and close the action on it, then push a rod of approximately bore diameter through the muzzle until the end comes in contact with the bullet of the cartridge in the chamber. In this position, put a scratch mark on the rod, even with the muzzle. Then remove the cartridge from the chamber and insert a bullet of the same kind that the cartridge is loaded with, pushing this up against the throat with a short rod or stick. While the bullet is held up against the throat, push the measuring rod against its point and make another mark on the rod even with the muzzle. The distance between the two marks on the long rod will indicate the amount of normal jump.

A rifle that has been fired a great deal, but well cared for, will show a considerable amount of wear or enlargement at the rear end of the barrel. This wear is caused by friction, erosion and probably to a certain extent by the compression exerted by the expanding or upsetting of flat base bullets. As this wear progresses, the accuracy of the arm begins to fall off, being first noticeable at the longer ranges. The bullet continues to have an increasingly greater distance to jump before it strikes the rifling, with a consequent increased deformation of the bullet, which in turn increases the yaw. As the dispersion caused by yaw increases with the range, this explains why some rifles will shoot well at the shorter ranges but will shoot all over the lot at long range.

I am sorry to have taken up so much space on this subject of yaw but it is one of the most important factors 347
affecting accuracy and of the utmost importance to extreme accuracy; unless the reader has a pretty good idea of its causes and affects, he cannot hope to understand the means for reducing it.

Bullet Rotation.

In order to travel on its long axis, the bullet must be

given a proper degree of spin by the rifling. The amount of spin necessary depends upon the length of the bullet, which is usually measured in calibers. The degree of spin that a bullet receives is dependent upon the pitch of the rifling and the muzzle velocity of the bullet. In addition to these factors, the amount of spin that a bullet must receive depends upon the range at which it is fired. We have been discussing initial yaw and at the same time using the word yaw rather loosely in referring to it, but yaw also takes place when the bullet has lost too much of its forward velocity and spin in passing through the atmosphere. This yaw begins to take place in the descending branch of the trajectory, or after the bullet has begun to drop appreciably and when the axis of the bullet is no longer parallel to a tangent of the trajectory.

It is, therefore, possible for a long bullet, fired at a moderate velocity, from a rifle having a slow twist of rifling, to be accurate at short ranges but because of its slow spin, yaw will set in more quickly than it would with a shorter bullet fired from the same arm at the same velocity, or a bullet fired with a higher rate of spin. We find examples of this in the old black powder rifles. For example, take the .32-40. This arm normally has a pitch of rifling of one turn in 16 inches and using bullets well over three calibers in length it has made remarkable groups at 200 yards. Nevertheless, the same loads which have given such accurate results at 200 yards frequently will not shoot for sour apples at 500 because of the slow rotation of the bullet.

While no definite rule can be laid down here for the multitude of combinations of bullets, rifles and loads that are available, to say nothing of the ranges at which they 348
may be fired, it is a good rule of thumb to use the shorter bullets for short range, low velocity loads and the bullets of normal or slightly longer than normal length at higher velocities and at longer ranges, as the increased velocity necessary for the longer ranges will give the bullets a higher degree of spin.

Measuring the Pitch of Rifling. I believe that all handbooks on reloading religiously give directions for finding the pitch of rifling in a barrel without giving the slightest intimation as to why anyone would want to make such a determination. There is, however, a very definite use for a knowledge of the pitch of the rifling in the barrel, especially in loading ammunition for extreme accuracy. If the pitch of rifling and the muzzle velocity are known, the rate of the spin of the bullet is easily computed. If we have a load for our rifle that is giving satisfactory accuracy and we wish to use a different bullet that is of greater or lesser length, we can, by determining the pitch of the rifling, arrive at a rate of rotational velocity of the bullet. If the new bullet is longer, we can with the aid of the pitch of rifling, arrive at a muzzle velocity for it that will give it an equal or greater rotational velocity than the load we have previously been using—always taking into consideration the chamber pressure that must be developed in producing such a velocity.

As to the rotational velocity that any bullet requires, no definite rule can be given here, but a knowledge of the rotational velocity is certainly of as much practical value to the handloader as a knowledge of the muzzle velocity, as the two are inter-dependant.

Instability or yaw in bullets will make itself apparent on the target in the form of slightly elliptical holes, due to the tipping of the bullet. The yaw may only make itself apparent by leaving one edge of the hole darker than the other. Whether this condition is due to unavoidable faults in the arm, the bullets, or both, or merely to insufficient
349 speed of rotation of the bullet can only be determined by experimentation.

The simplest way of finding the rate of twist in a barrel is to use a tight fitting patch in a slotted rod, forcing the patch into the grooves and working it back and forth until it will move with a fair degree of ease. Push the patch down the bore well towards the breech and make a small mark on the top of the rod coincident to another mark made on the muzzle of the barrel. Then draw the rod back until it makes one complete turn; with the mark on the rod coming to the top. Make a second mark coincident with the mark on the muzzle, measure the distance between the two marks on the rod and you will have the distance in which the rifling makes one complete turn. If a slotted rod is used and the patch is a tight fit there is not likely to be any movement between the rod and the patch but even if there is, it will be negligible from a practical standpoint. A little more certain but less convenient way of arriving at the same result is to force a bullet through the barrel so as to impress the rifling into its surface and then solder this slug securely to the end of a rod, after which the slug may be reentered into the barrel and the same procedure followed as with the patch.

Measuring the Bore and Groove Dimensions. A knowledge of the bore and groove dimensions of a rifle barrel is desirable when loading for extreme accuracy so that a proper selection of bullets can be made. Of course, sometimes these dimensions will turn out to be so cockeyed that the barrel cannot be properly fitted, but at least one knows where he is at. To do this the barrel should be thoroughly cleaned, oiled with light oil and most of the oil wiped out. It is only necessary to leave a trace of oil in the barrel. A bullet, preferably a cast bullet of pure lead or of a soft alloy, hammered on the end so that it will upset to a diameter larger than the groove diameter of the barrel, is then placed on the muzzle and driven into it with a short rod, taking care that the rod does not strike the rifling.
350 It is advisable to use a piece of brass rod. Any piece of lead can be hammered up into a rough slug for this purpose, but it is important that it be large enough so that metal will be sheared off all around it when it is driven into the muzzle. This will insure a full impression of the rifling on the slug. Once started the slug can be tapped or pushed through the bore with a long rod and caught when it comes out the other end so that it will not strike any part of the gun or drop on the floor and become deformed. However, if it does, don't worry about it, because the deformation will be confined to one edge. It is best to use a slug that is at least two calibers long.

The high spots on the slug will represent the grooves and the low spots the lands, as the surface carries a negative

impression of the rifling.

The groove diameter can be found by measuring diametrically across the ridges on the slug but it will usually be found that the diameter measured across the edges of these ridges will be greater than the diameter across the center of the broader surfaces, and the greatest diameter of the slug should be taken as the minimum groove diameter of the barrel. This difference in diametrical measurements is caused by the fact that rifling cutters, used to cut the grooves in the barrel, are stoned or sharpened with the eye alone as a gauge and they seldom cut in a true arc.

Where the rifling has an uneven number of lands and grooves the measurement is not so simple. In such a case it is necessary to measure from the right hand edge of one ridge on the slug to the left hand edge of the ridge most nearly opposite it. The measurements should be taken across several of these diameters and care must be used, as a micrometer caliper has a powerful screw and these edges of soft lead do not offer much resistance. In doing this, don't worry too much about .0001", if the micrometer has a vernier, because the best of hand micrometers will not measure to a .0001" with certainty, regardless of the fact that they are graduated in this way.

In measuring bore diameters it is frequently possible to 351
measure across the bottoms of the grooves in the slug, provided that they are wide enough, so that the measuring surfaces of the micrometer will not first come in contact with the ridges on the slug. In case this latter occurs, it is necessary to carefully cut away at least part of these ridges so that the low spots can be measured without interference. Incidentally, any diameter of the grooves in the slug will give the bore diameter of the barrel, because these are true arcs inasmuch as the bore is round.

The measurement of the bore diameter of a barrel with an uneven number of grooves is not so easy as the measurement must be made from the corners of grooves in the slug that are diametrically opposed to one another. This necessitates measuring with the edges of the micrometer measuring surfaces and measuring from an edge is unreliable, but is the best that can be done under such circumstances.

Measuring Chambers. As the dimensions of the chamber have a limiting effect upon the accuracy that can be obtained it is sometimes interesting to compare the measurements of the chamber with a factory cartridge. To make a measurement of this kind accurately is not simple without special gauges but the following method will be found reasonably satisfactory.

Clean and oil the chamber and barrel for about an inch ahead of the chamber. Wipe out all the excess oil so only a trace remains. Plug the barrel with a wad of cotton about an inch ahead of the chamber and stand the rifle on its muzzle with the barrel as nearly vertical as possible. Then melt some sulphur in a ladle that will hold more than the volume of the chamber. If you have no such ladle, use an empty can with one side bent into an acute V for a spout. You will have to rivet a handle onto the can or handle it with a pair of pliers for, while sulphur melts at a low temperature, the can will get too hot to handle. The combustion point of sulphur is low and if you use too much 352
heat in melting it, it will ignite and give off pungent and offensive fumes that are sure to bring you into disrepute with everyone in the vicinity.

When the sulphur is all melted, pour it carefully into the chamber. It will shrink considerably on cooling and you must continue to pour into the shrink hole as it solidifies in order to fill the chamber. When thoroughly hard, the cast can be removed by pushing it out with a cleaning rod. A slight blow may be required to start it and you should be careful that it does not drop and break. This cast will give you a full impression of the chamber, throat and part of the rifling. It is advisable to make such measurements as you want promptly because the cast will warp and shrink after a few hours.

Now that we have the sulphur cast we come to the difficult job of measuring it. Fortunately the neck of the chamber is the most important part and is easy to measure. It is also simple to measure the diameter of the larger end of the chamber but one should remember that the cast is soft and that a light touch must be used. Due to the taper of the chamber one will usually be measuring with the edges of the measuring surfaces which is undesirable but, with care, it should be possible to get within one thousandth of an inch of the correct dimension.

Measuring the diameter at the shoulder of a bottle neck chamber is less easy and reliable, and much will depend upon judgment. At this point it is not only necessary to measure with the edge of the micrometer anvil, but also to measure to an edge on the cast. Furthermore, the "edge" on the cast isn't an edge at all as there is a radius where the body of the chamber meets the shoulder. It is often difficult to tell just where the body ends and the shoulder begins, but with care the measurement will be close enough for any use a reloader will have for it.

Loading Density and Its Effect Upon Accuracy.

The position of the charge in the cartridge case will have some effect upon the way it burns. For example, let us 353
suppose that a powder charge occupies less than half the capacity of the case. If the charge is distributed evenly along the case when the cartridge is fired, the flash from the primer will sweep across the top surface of the charge. If, when firing the next cartridge, the muzzle of the rifle is elevated and the powder settled back in the rear of the case, the primer flash will penetrate the charge, and a different order of ignition will result. To be sure that the position of the charge is uniform from one shot to another, the muzzle of the rifle should be elevated to settle the charges in the rear of the chamber, and bring the rifle down to the aiming position with as little disturbance as possible. The higher the density of loading, or in other words, the larger the volume of the powder charge in relation to the volume of the powder chamber, the less important the position of the charge becomes. It is of great importance when using small charges of pistol powder in a large case and of negligible importance when full charges are used.

Seating Depth of Bullets.

The accuracy of any rifle can be improved by loading

the bullets so they are seated far enough out of the cases to be in contact with the throat of the barrel when the breech block or bolt is closed on the cartridges. This usually makes the cartridge too long to work through the magazines of repeating arms but it has a very beneficial effect on accuracy for a number of reasons.

With the normal amount of jump that a bullet has before coming into contact with the throat of the barrel, it must strike a severe blow against the rifling and it is only reasonable to suppose that this blow increases the intensity or violence of the barrel vibrations. It does not hold that the blow causes a change in the vibration cycle, provided that the direction and force of the blow is always the same, but here is the stumbling block. After the case has let go of the bullet and left it hung in the air, so to speak, it is purely a matter of chance as to what slight angular direction the bullet will take before it strikes the 354
rifling. A difference in the direction of the blow from one shot to another will cause a difference in the character of the barrel vibrations and in the directional movement of the muzzle caused by them. On the other hand, if the bullets are seated out of the cases far enough so they are in contact with the rifling at the instant of discharge, the blow is reduced and as the bullet will normally be pretty well centered by its contact with the throat, other loading conditions permitting, the variation in the barrel vibrations are minimized. There is also less chance for the bullet to become deformed in the barrel. Regardless of causes, reasons, or suppositions, the hard fact remains that any rifle will give better accuracy if the bullets are loaded far enough out of the cases so that they are in contact, or nearly in contact, with the rifling when they are fired. It is essential, however, that all of the cartridges be loaded in the same manner for if one bullet is allowed to jump and strike the rifling, while another is in contact with it, the finest of accuracy cannot be expected because of the difference there will be in the barrel vibration, which in turn will make some difference in the angle of departure of the bullet.

Because of the lack of shock on the bullet, those that are seated so that they fit against the rifling when the cartridge is fired are less liable to deformation in the bore and consequently less liable to yaw than those that are loaded in the normal manner. If one stops to consider the fine accuracy that is obtained from most rifles using cartridges loaded in the normal manner and from which the bullets jump before they strike the rifling, it will be realized that the benefit gained from seating the bullets in contact with the rifling before they are fired is at best limited. Nevertheless, it is one of the most important things that a reloader can do to obtain the best accuracy from any given rifle. Special barrels, and particularly heavy barrels made especially for target shooting, are almost always throated more closely than ordinary commercial arms so as to reduce 355
bullet jump and special match ammunition is often loaded with the bullets projecting far enough to be in close contact with the throats of the arms they are intended to be used with. A change in bullet shape is sometimes resorted to in order to accomplish this purpose also. This is especially true of long range match ammunition.

To determine the proper seating depth for a bullet, start one into a case for about half of the usual seating depth and try the cartridge in the chamber of the rifle. Do not try to force it, but merely use enough pressure on the bolt to bring the bullet into firm contact with the throat. If the action will not close, seat the bullet a little deeper and repeat the process until the bullet is just in firm contact with the rifling when the bolt or breech block is fully closed. If undue force is necessary to close the bolt and lead alloy bullets are used, the bolt will act as a bullet seater but, unfortunately, some bullets will be forced deeply into the rifling, while others will "back up" into the cases, making for a lack of uniformity.

In loading for extreme accuracy cartridge cases should not be resized full length nor should the necks of the cases be resized to the distance that the bullets are to be seated. Just how the bullet is to be held in place will depend upon circumstances. If, when it is seated to the proper depth, the mouth of the case comes opposite a lubrication groove on a cast bullet or where there is no cannelure in a jacketed bullet, the neck of the case should be resized just far enough to hold the bullets friction tight so they will not fall out from ordinary handling. If there is a cannelure on the bullet that comes even with the mouth of the case or a band or other surface into which the case can be crimped, a light crimp should be used. Either method should leave the bullets so they can be wiggled slightly with the fingers. When a cartridge so loaded is chambered the force necessary to move the bullet in the case will be less than the force necessary to move it off center into the throat and 356
the bullet will properly center itself in the throat. Remember, it is the relation of the bullet to the *throat* of the barrel and not to the cartridge case that counts. Naturally, if the ammunition is to be subjected to much handling the bullets will have to be seated more securely, but for *accuracy* the above method will be found to be the best. The only better way is to go back to the old "scheutzen" bullet seater and load the bullet separately from the case and powder charge.

The importance of the relation of the bullet to the throat at the instant of firing cannot be over emphasized. All the refinements of close chambering have this objective. The neck of the chamber is the most important part and, all other things being equal, a cartridge that fits its chamber closely at the neck when loaded normally will develop better accuracy than one fitting loosely at the neck. The above method of loading in which the bullet is allowed to center itself in the throat will give good results even in a poorly chambered arm.

Alignment of Bullet With Case.

Elsewhere I have stated that it makes little difference how bullets are seated as long as the loaded cartridge is within the tolerances of the chamber it is to be fired in. This means that the bullet must be straight enough so that it will not bind or be forced against one side or the other of the throat. The obvious and logical reason for this statement has also been explained but this does not mean that carelessness or indifference to the way bullets are seated

should be permitted, for it is always well to be careful of this detail and seat the bullets as perfectly as possible.

When loading for extreme accuracy, special pains should be taken in seating bullets. If anyone were to hand you some cartridges that had the bullets seated a trifle cock-eyed and you didn't get quite as good a group as you expected from your holding, the chances are that you would swear that the trouble was with the way the bullets were seated. Actually, that might not be the reason at all but the assumption is a natural one for any of us; we can see 357
the irregularities in bullet seating but we can't see many of the other conditions that make for the best of accuracy.

If, when loading for extreme accuracy, we take pains with the seating of bullets as well as with all other details of the loading, this mental hazard is removed. We *know* that we have done a good job on the ammunition and, granting the proper shooting ability, if the ammunition doesn't shoot properly, the factors affecting the shooting, both in the arm and the ammunition, can be run down one at a time.

As to the exact methods to be employed in the seating of bullets, I know of no loading tool that will not seat bullets well if it is properly used. Theoretically, the straight line tools have a slight advantage over the tong tools, but actually the former seldom do the better work. The only tong tools in common use are the Bond Model "C," and the Ideal models but these two makes do not work on the same principle. The chambers of the Ideal tools have a recess which guides the necks of the cases before they come in contact with the crimping shoulder and the cases are guided at the heads, but they are forced into the tools practically in a straight line because they can't go anywhere else. This is not quite true of the tapered cartridge cases, as the full guiding effect of the guide hole in the tool does not come into play until the handles are nearly closed.

In the Bond Model "C" tool, the case is not guided at the neck at all. It is only guided by the bushing, and the case muzzle can move about in any direction that the pressure of the closing handles makes it and the bullet, by the resistance it offers, has to straighten the case up. If bullets are seated with too sudden a pressure in this tool, they are apt to seat at a bit of an angle with the axis of the case but with a slow steady pressure they do very well. For the best results, the bullet should be just started into the case, then the cartridge turned half way around to complete the seating. This reverses the direction of thrust imparted by the tool handles and aids in seating the bullet 358
straight. The same chambers used in the Bond Model "D" tool are not open to this objection, as in the straight line tool the side thrust is not present. It is essential, however, that the bullets be started straight with the fingers before completing the seating of them with the tool.

Straight Line Bullet Seaters. In addition to the universal loading tools that perform all of the loading operations, including the seating of bullets, there are the straight line bullet seaters. These bullet seaters, which perform only this one operation, take the form of a long die with a chamber or recess conforming to the shape of the cartridge they are made for and are similar to a section cut from the rear of a rifle barrel with the rifling reamed out. The "bore" part is smooth and of bullet diameter. The charged cases are entered in the chamber, one at a time and a bullet dropped into the bore base first. The seating of the bullet in the case is accomplished with the aid of a plunger having a recess in its lower end which fits the point of the bullet. Some of the plungers, notably in the Belding & Mull bullet seaters, are adjustable for length so that the depth of seating of the bullet can be varied as desired, but other special tools of this nature are non-adjustable. In principle, this is the perfect method of seating a bullet and in loading ammunition for arms with special barrels and unusually tight chambers, it is the only satisfactory way to do the job.

Some of these special chambers are so tight that commercial ammunition will not go into them. The case necks have to be turned and reamed to make them the exact size of the chamber neck and of a uniform wall thickness. Any irregularity of the case, or angular seating of the bullet, will prevent the cartridge from entering the chamber properly. Straight line bullet seaters for such rifles are usually chambered with the same identical reamer used in cutting the chamber in the barrel; being carefully hand reamed, both chambers are essentially alike. This represents 359
the ultimate in a bullet seater and while such a combination of arm and loading tool is, in a sense, impractical, it does make for fine accuracy.

But all the care in the world that may be taken in seating bullets will not make an over-bored or loosely chambered rifle shoot as well as a more perfectly made arm. However, by studying the peculiarities of the arm and using care in the loading of the ammunition for it, the shooter will develop the best accuracy it is capable of.

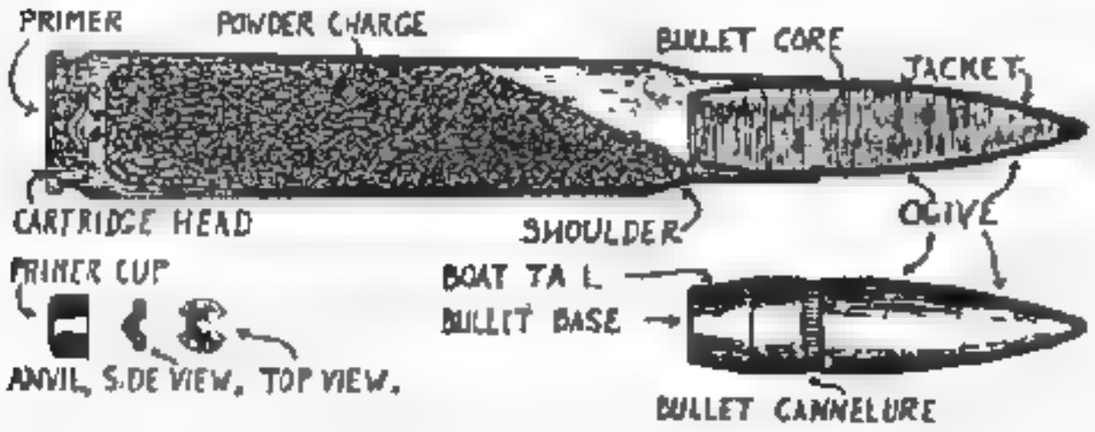
"Accuracy."

In discussing the simpler phases of reloading, a number of statements were made regarding the limited effect on accuracy of certain little irregularities such as variations in crimp, imperfections in the points of bullets, etc. From the viewpoint of the average reloader who wants ammunition that is easily and quickly loaded and that will give him a degree of accuracy probably equal to his shooting ability these statements are perfectly true. Any reloader can satisfy himself on this point by deliberately loading cartridges with minor defects of the types referred to and shooting them in comparison with others lacking such defects.

But "accuracy" is an indefinite term. A cartridge that is designed to plow through brush and strike a smashing blow under conditions where game can seldom be seen at as great a distance as one hundred yards need not possess target accuracy. As long as it will group its shots within the vital area of the animal, which may be 8 or 10 inches in diameter it can be called an "accurate" cartridge, yet it would be hopelessly "inaccurate" for target shooting. It is, however, generally accepted that ammunition that will group in three minutes of angle or three inches at one hundred yards deserves to be called "accurate" because it is possible, with care, to machine load ammunition to perform this well. The reloader will ordinarily have no difficulty in

loading ammunition with this degree of accuracy, but when one wishes to reduce the group size to two or to one inch at one hundred yards, careful attention must be given to 360 *all* details of loading *and variations must be reduced to the irreducible minimum.*

As the relation between arms and the ammunition for them is such an intimate one it is impossible to consider the one without the other.



"All there is to it"

Priming.

If the proper ignition of a power charge is important in the ordinary run of ammunition (and it is) it is much *more* important when we seek extreme accuracy. The reloader will do well to give special attention to his primers and the way they are seated. All makes of primers do not develop the same flash and heat. One make may be found to ignite some kinds of powders better than another even though both are recommended for the same cartridges. If, in spite of extreme care in loading, the groups have a tendency to string up and down, the primer should be suspected and a different brand tried. The primer pockets in different makes of cases may be of different *depths* even though they are of the same *diameter*. If a primer intended for one of the deeper pockets is loaded into a case with a shallow pocket, the combined effect will be the same as adding a few thousandths of an inch to the length of the firing pin and pierced primers or lesser ignition difficulties may result.

It is good practice to clean the primer pockets with a bit 361 of cloth on the end of a stick. The amount of fouling left by a primer is not of much consequence but sometimes it is of a flaky nature, and if imprisoned under the edge of an anvil it may slightly cushion the blow of the firing pin. Some of the newer primers are quite critical in this respect, and the reloader seeking the finest accuracy should not hesitate to turn to the old reliable (even though corrosive) chlorate primers.

Powder Charges.

The Ideal, Bond and Belding & Mull powder measures will all throw charges with surprising uniformity once they are properly set. In fact, when Capt. G. A. Woody was developing the .22 Hornet cartridge he found the charges thrown by an Ideal Measure so accurate that he discontinued weighing his charges. All of the above measures are about on a par as to uniformity of charges, but this uniformity *decreases* as the size of the powder grains *increase*. In other words they will not measure coarse grain powders with the same accuracy and uniformity as fine grain powders.

A scale or balance sensitive to one-tenth of a grain is almost a necessity when loading for extreme accuracy. Any of the scales or balances of the tolerance mentioned that are offered by the reloading tool manufacturers are satisfactory. The Pacific Scale is worthy of special note as in addition to being as accurate as any of the other powder scales it has the added advantage of being inexpensive.

The scale or balance can be used in connection with a powder measure by setting the measure for a charge slightly under the weight desired, dumping the charge from the measure into the pan of the scale, and then adjusting the charge on the scale by adding the small amount of powder necessary to bring the scale to balance. This will speed up the work a little without any sacrifice in accuracy.

While a tolerance of one-tenth of a grain is unnecessarily small in a heavy charge as well as being of doubtful attain- 362 ment, it is nevertheless advisable to eliminate all possible variations when loading for extreme accuracy. If a greater variation is permitted, and the resulting groups are good except for one or two shots, it is only natural to blame the strays on the powder charges without really knowing whether or not that was the cause. Therefore, regardless of the fact that powder charges can be considered as accurate if the variations are within 1% of the weight, it is advisable to hold the charges as close as the accuracy of the scale used will permit.

Selection of Bullets.

Elsewhere in this book it has been stated that minor defects or irregularities in the sides or points of cast bullets can be ignored provided the bases are sharp and cleanly cast. This is true insofar as ordinary accuracy is concerned, but when one is loading for the finest possible accuracy no defects of any kind should be overlooked. Failure of the bands to fill out as sharply on one side of a bullet as on the other, or the presence of a fold or wrinkle in the point will naturally have some effect on the balance of that particular bullet. Bullets with minor blemishes *may* shoot into the group, but they *may not*. It is best to select only those that are perfect, reserving those with little defects for your ordinary run-of-the-mill target shooting. Cast bullets should be checked for roundness before they are sized. To do this, use a micrometer caliper, measuring the diameter of the bullet at right angles to the joint line and again as near to the joint line as possible. Do not measure it at the joint line as it will probably be slightly larger at this point, the joint line being taken off in the sizing of the bullet. All bullets will not measure exactly the same as they come from the mould. That is the reason moulds are made to cast bullets slightly larger than necessary so the little inequalities can be eliminated by sizing them. If, however, the bullets are more than a thousandth of an inch out of round, you may have to use another mould (although you probably won't have to).

363 Bullet temper may have to be varied in order to improve the accuracy of a load. There is no rule for bullet temper except that the harder the alloy the less temperamental it is likely to be. After you have shot enough groups with a bullet to satisfy yourself as to its capabilities, try the same load with bullets a little softer or a little harder. If you

then find an improvement in accuracy change the alloy again and continue experimenting until the accuracy begins to decrease. Only in this way can you find the alloy best suited to that particular bullet and load.

Your bullet lubricant may also have to be given attention. Read the chapter on "Bullet Lubricants" before you begin reloading for extreme accuracy.

When loading metal jacketed bullets for extreme accuracy the bullets should be selected for uniform diameter. Flat base bullets are alright if slightly under the groove diameter, but boat-tail bullets should be full groove diameter. Uniformity is more important than the exact diameter determined upon. To select jacketed bullets a micrometer caliper with a lock or clamp is a convenience. If, for example, the groove diameter of your barrel is .308 inch, lock the micrometer at .308, and reject all bullets that pass through. Then reset the caliper to .3085 inch and reject the bullets that do not pass through. This gives a maximum tolerance of only one-half thousandth of an inch which is pretty close and a tolerance of one-thousandth is permissible. As a rule, jacketed bullets should not be more than one thousandth of an inch larger than the groove diameter of a barrel. The bullets that do not gauge to your adopted standard can be measured and segregated into lots according to their diameters.

For the best accuracy, especially for long range shooting, the bullets should be weighed. One per cent of the weight is a reasonable tolerance, but you can hold them as close as you like. Set the scale for the minimum weight and reject the light bullets. Then repeat the process with the scale set for the maximum weight and reject the heavier ones. The rejects can be separated into lots, but naturally, 364
cartridges loaded with these different lots should not be mixed, as this would put all your careful work to naught. Lead bullets should be weighed *after* they are lubricated as the lubricant is part of the weight that must be driven forward by the charge.

Naturally, a bullet whose axis does not pass through the center of both ends cannot be expected to develop the highest degree of accuracy. Spinning is sometimes resorted to to verify the concentricity of bullets. The body or cylindrical portion of the bullet is either held in a chuck or collet while the bullet is spun or it is rolled in such a way that any eccentric movement of the point (or boat-tail) can be observed.

As to the fineness with which eccentric bullets can be detected by spinning the writer will not express an opinion but will let the following story speak for itself. A certain lot of match bullets were being produced and were being spun to check their concentricity. Naturally, this resulted in some rejections. The writer surreptitiously took a handful of rejects and handed them to the inspector. About one-third of them were passed as perfect. The same trick was tried with the "perfect" bullets. One was rejected.

Nothing in the foregoing remarks is intended to convey the idea that spinning or otherwise verifying the concentricity of bullets is a superfluous or useless operation when loading for the finest accuracy. Factory bullets are occasionally appreciably eccentric, and it is desirable to eliminate such bullets or, at least, to segregate them and use them in ammunition for ordinary shooting purposes. Judgment must be used when spinning cannelured bullets as the cannelure sometimes sets up a little ridge on the bullet that will prevent its being spun evenly and unless the person doing the spinning has had considerable experience he may get fooled and reject many perfect bullets. Spinning lead bullets is a waste of time.

Spinning loaded cartridges for concentricity is also a
365 useless labor. It is the relation of the bullet *to the throat of the barrel and not to the cartridge case* that counts.

Anyone who has reloaded small arms ammunition and has had anything to do with the firing of sea coast cannon could hardly help drawing an analogy between the two. The lone individual who weighs his powder charges and bullets and fusses over little details is often regarded as a harmless lunatic or "nut" by his less enlightened brethren, but let us just draw a few comparisons in his defense.

No battery commander would think of taking projectiles and powder charges out of a magazine and firing them as they are. The paint is first scraped off the "bourrelets" of the projectiles (the forward bearing surface that rides on top of the lands), and they are gauged to make sure they are the right size for the gun they are to be fired in. Any bad burrs or flaws in the copper rotating bands that take the rifling are filed or hammered out. This is the equivalent of the hand loader calipering his bullets.

The next job is to weigh the projectiles and group them according to their weights. Every gun has a "probable error" which corresponds to the grouping ability of a rifle. Projectiles of different weights will give different muzzle velocities. If the projectiles are fired without consideration as to their weights the dispersion will be greater than the probable error of the gun and some one will be in trouble. Therefore, the projectiles are weighed and separated in lots even as we weigh and classify our bullets. There is one big difference in that weighing 12 inch projectiles of a half ton or so each cannot be considered merely a pleasant pastime.

Next the powder charges come in for consideration. In large caliber guns the powder is loaded separately from the projectile. The powder is put up in cylindrical silk bags and for the larger guns the charge is contained in two or more bags for convenience in handling. These bags of powder are weighed also and powder added or taken out to bring them to the proper weight—just as the handloader
366 checks his powder charges on scales after the powder measure has thrown the charge. Now that we have weighed and gauged the "bullets" and weighed the powder charges, let's take a look at the loading process.

The gun, of course, is constantly kept laid by the gun crew on the basis of data furnished by the range finding detail. When all is ready the command comes; "TARGET." Second target in rear of U. S. Tug, General Fulano. Fire four trial shots. Commence firing!

A truck, adjusted to the proper height, and carrying one of our "hand weighed" projectiles, is rolled up to the breech of the gun, as like as not chalked up with pictures, blessings, admonitions and prayers for its arrival at the

target. Almost before it is in position, the ramming detail have the end of a long rammer against the base. At the command; "Home-RAM" they give the rammer "the works" and the projectile is socked up into the forcing cone of the gun with a resounding "BONG." The projectile truck is pulled out of the way and the powder bags are pushed in, the breech closed and a primer is inserted in the breech block. The gun is tripped and goes up into battery, and at the proper instant WHAM! Off she goes and the recruits start for home.

Now let's take a closer look at the loading operation. The projectile *must* be rammed hard and uniformly, and ramming is the most important part of the loading. If the projectile should fail to stick up in the forcing cone (corresponds to the throat of a rifle barrel) it would not only fail to go where it was intended, but would increase the density of loading and consequently the pressure to a dangerous point. Projectiles that slip back have, can and will raise the devil with a gun and sometimes it doesn't have to happen more than once to put the gun out of commission.

The ramming of the projectile is similar to seating a bullet far enough out of the cases so they will be forced into the throat firmly.

From the sketchy description given I believe it will be perfectly apparent that long range cannon are normally 367
loaded "for extreme accuracy" and that the reloader who takes the pains to apply the same common sense principles to obtain better than normal accuracy from his rifle is anything but a "nut."

Common Sense Reloading.

The old saying that "a little knowledge is dangerous" can, for reloading purposes, be paraphrased to "a little knowledge is sometimes confusing." Beginners at the reloading game are apt to read a lot of explanations and get an exaggerated idea of the importance of little details. The writer has come in contact with many beginners at the reloading game who were overlooking entirely some of the more important simple fundamentals of reloading because their heads were cluttered up with partly digested thoughts about barrel vibration, variations of tenths of grains in bullet weights and numerous other picayune details. Common sense is one of the most important things that can go into the reloading of a cartridge. For the benefit of any beginners at this interesting and profitable pastime who may have become confused by any of the foregoing comments the following brief proletarian remarks are made:

1. Use cartridge cases that are all of one make and primers that are of the same make as the cartridge cases.

2. Wipe the primer pockets out with a piece of cloth on the end of a small stick, and be sure that the primers are seated with an even pressure, but that they are forced fully to the bottoms of the primer pockets.

3. Measure or weigh your powder charges so that they do not have a variation of more than 1% of the weight of the charge. In a 50 grain charge this would mean a tolerance of ½ grain in weight. This is a very liberal tolerance, and charges can easily be held much closer than this.

4. Metal jacketed bullets can be used just as they are purchased without gauging, weighing or spinning because 368
the factory metal jacketed bullets being made today run very uniform.

5. Seat the bullets out of the cases far enough so that they are just in contact with the rifling when the action of the rifle is closed on the cartridge.

If the foregoing simple details are observed and you find on getting out to the range that someone else is getting better results on the target than you are, it will probably be due to the fact that that individual either is a better shot than you are or has a more accurate rifle.

• • • •

Like all other things, whether good or bad, this book must come to an end. In reading over the galley proofs I find many shortcomings in the work; places where other topics, comparisons and explanations might well have been used. However, the book already exceeds the length stipulated by my publisher and no more can be added to it. It is doubtful if any one book on the subject of handloading ammunition can ever be complete, embracing as it does the broader subjects of chemistry, physics, metallurgy and explosives, all of which are in a state of constant development. The best that can be done is to try and crowd as much information as possible into the limited space allotted and in doing this I have tried to write in a way that will be understandable to the novice at handloading and at the same time make the work useful for the experienced.

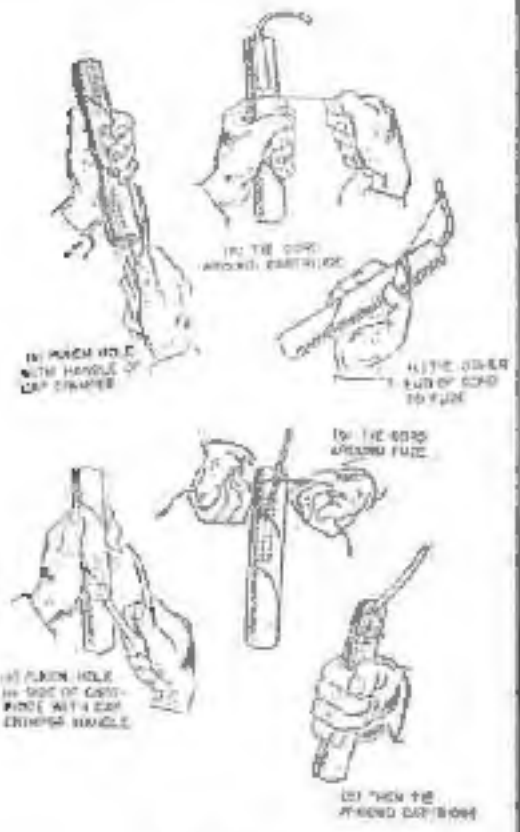
Before I set aside the old Royal, which I will do with physical relief but mental reluctance, let me remind the beginner once more that the mechanics of loading ammunition are very simple. It is the attention to, and the understanding of, the smaller details that make the difference between mediocre and good ammunition. I believe that 369
the information in this book, if properly understood and applied, is sufficient to solve almost any problem that may arise. However, if there are any points that are not clear or the reader can not work out his own salvation from the text, I will esteem it a personal favor if he will write me and state his problem. I will be only too glad to assist him to the extent of my ability.

EARL NARAMORE,
Yalesville, Connecticut.

September 1, 1937.

The Poor Man's JAMES BOND VOL. 4

Kurt Saxon



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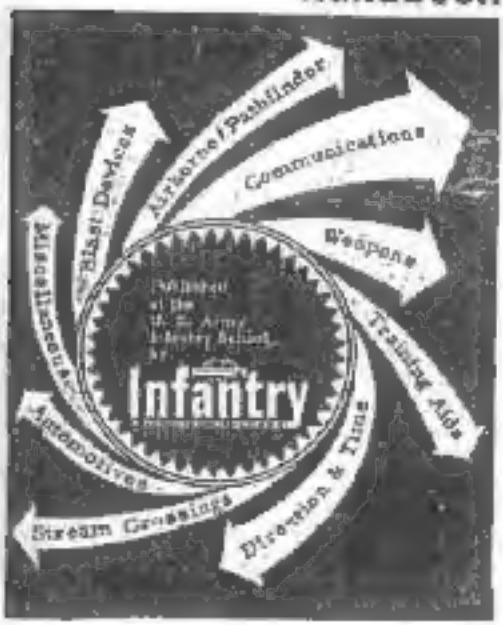

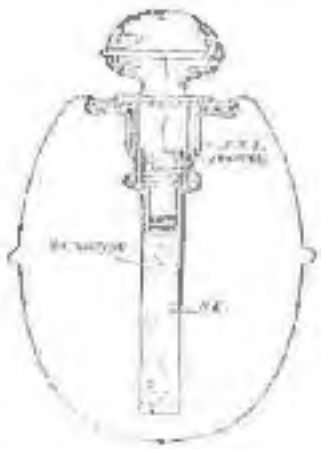

SAPPER!

ENGINEER SOLDIER'S HANDBOOK

VIET CONG BOOBYTRAPS

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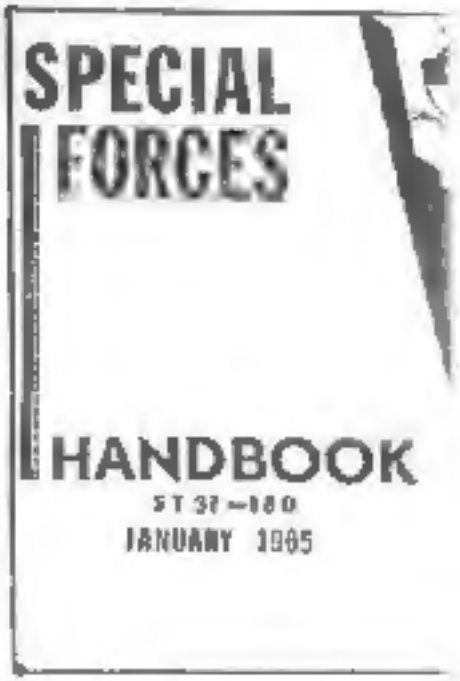

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